# PETROLEUM REFINER

SPECIALIZED FOR THE OIL REFINING INDUSTRY, INCLUDING PETRO-CHEMICAL ENGINEERING, PETROLEUM SYNTHETICS AND NATURAL GASOLINE

June, 1944
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*Editor*


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# CONTROLLING FACTORS *in* SYNTHETIC RUBBER

VOLUME 23, NO. 6 JUNE, 1944

PETROLEUM
# REFINER

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A GULF PUBLISHING COMPANY PUBLICATION

## THE LOOK BOX

**For You And Me**

WHEN Dr. Willard H. Dow accepted the Gold Medal Award of the American Institute of Chemists last month, his acceptance had a ring of truth which puts meaning into the American way. Anyone disposed to accept this American way as an accident can get quick disillusionment by reading the speech, printed elsewhere in this issue.

It is a departure to use such material, since his remarks contain no direct reference to the petroleum industry. His observations are too fundamental for such restriction. His opinion is that the American system of living and doing business had its start as a worthy objective, and he gives a warning that all of this can be lost by following myths, which will destroy the reality so well established.

**Its Own Money**

ONCE the war is ended the refining industry will benefit from having put so much of its own funds into wartime expansion. Of the $760,000,000 that finally will be spent for equipment to make 100-octane gasoline, $550,000,000 came out of the industry. The plants represented in this part of the program can be put to making motor gasoline or other products at the will of the ownership, leaving plants included in $210,000,000 of construction to be adjusted in cooperation with government agencies.

On an output basis, 82 percent of the aviation-gasoline capacity is privately owned, consequently only 18 percent of the capacity will be subject to orders from Washington.

**C'est la Guerre**

WHILE manufacturers of refinery and natural-gasoline-plant equipment are having trouble in making delivery on the equipment their customers would like to have, and while refineries and natural-gasoline plants face a serious problem by reason of equipment and manpower shortages, publishers of oil papers, too, are having their problems and for identically the same reason—the war.

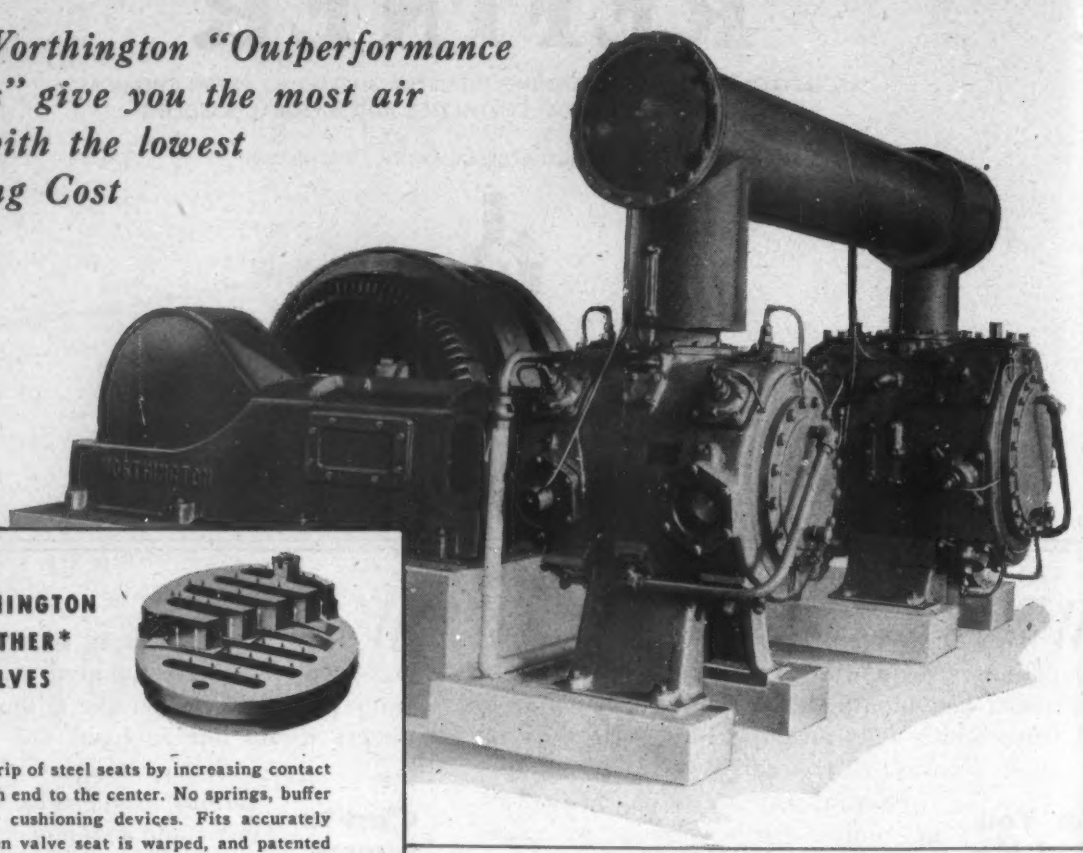
Steel, manpower and oil have all gone to war, and right along with them, paper has gone, too. From a practical standpoint it does not matter whether the steel, manpower, oil and paper are being wasted in the war effort in spots; the fact remains that oil publications have been drastically cut in the tonnage of paper available to them, and then, too, are exercising every possible ingenuity to meet the emergency.

In the case of PETROLEUM REFINER, paper stock has been reduced from 60 pounds to 35 pounds per ream. Incidentally, as the paper base weight is cut, the price per pound goes up, with the result that a ream of 35-pound stock now costs as much as a ream of 60-pound stock cost prior to the war. In addition the lighter weight paper has slowed down press production at a time when the manpower problem is as serious in the printing plant as it is in the refining plant. Further economies have been effected through closer trimming of the borders, that is, reducing the overall page size without reducing the type size.

Along with the reduction in paper weight has come inadvertently a reduction in the quality of paper stock. The lighter paper makes it more difficult to achieve satisfactory reproduction and

# "SO MUCH — FOR SO LONG — FOR SO LITTLE"

*Three Worthington "Outperformance Features" give you the most air power with the lowest Operating Cost*



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*There are three reasons:*

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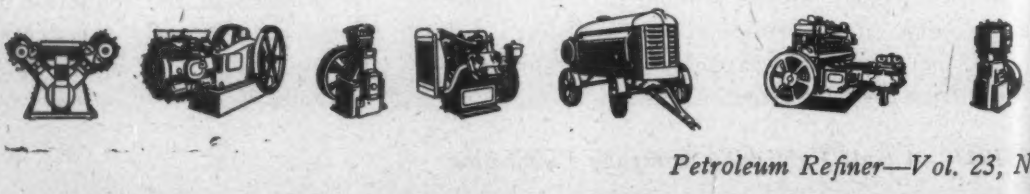

more time is spent on the press to achieve results, which would have been nothing to boast about in prewar days.

Another approach to better use of a limited paper allowance is to adopt a smaller type face for the technical section of PETROLEUM REFINER. This is under consideration and a decision will be made soon.

Early in April the publishers of PETROLEUM REFINER were forced by reason of the paper situation, to advise advertisers that we could accept no new contracts for advertising space for a period of 90 days—with the provision that a new look would be taken at the situation at the close of that period. At the same time the editors were advised that they were not to make any reduction in editorial content. Subscriptions have not been restricted and it is not the intention to do so, although this has been a procedure some publications have been forced against their will to follow. It is the thought of the publishers of PETROLEUM REFINER that if there be further paper reductions, they be made in the advertising section by asking advertisers to reduce their space. It is their hope, however, that provisions already taken will not further disturb allocation of space to present advertisers.

In our individual efforts to meet the problem, we have been faced with some problems peculiar to the oil industry. Thus far, our efforts have evidently been fully appreciated by both subscriber and advertiser alike.

For the forebearance of our subscribers and advertisers, we are deeply grateful. We, in turn, pledge the use of the greatest possible discrimination in selection of material to appear in PETROLEUM REFINER and pledge as well that on the conclusion of the war we shall return to the same quality and size of paper stock from which we have been forced by paper rationing.

## Postwar Program

THERE are indications that men are giving attention to postwar planning in the hope of arriving at some magic formula. The conferences, the speeches and the conversations grow in number, and the feverish interest is evidence that men are seeking a better set of conditions. That they want something different is understandable.

But it is doubtful that better conditions will come about through the finding of a magic formula. Fundamentally industry will not change. The mistake lies in such an expectation, for a failure on a postwar program will be accepted as a failure of industry, when in fact it will be the result of another failure of men.

Why a hope of magic formula persists is not easily explained, since the actual recommendations of what to do when the war ends are not of the exceptional classification. In wording they differ, but a study of several dozen plans for an industrial program at the end of the war come to these recommendations:

Industry should:

Provide better goods and services at lower prices;

Provide employment wherein the individual is adequately paid and encouraged;

Stimulate and support a continuous program of technical research;

Bear its share of civic and governmental responsibilities;

Provide a fair return on invested capital.

None of these differ from the obligations previous to the war. They may not be all the obligations of the industry but they are fundamental and they will not change so long as the concept of free enterprise is accepted.

The word "industry" is in need of definition. Somehow it has come to be accepted as involving only the invested capital or management phase of commercial activity. Under such a restriction, industry will fail. Industry involves labor as well as capital and management. Only the person blinded by class distinction will divide the worker in a plant from the worker in an office. Wages and salaries are two words of identical meaning, and the persons paid by each are working to one purpose.

The labor phase of industry is as responsible as the management phase of industry.

In much of the postwar planning the demand for full employment gets prominent mention and frequently there is an implication that management or the owners of invested capital is under compulsion to assure full employment. Management may desire such and strive to accomplish it, but it has no means of assuring it. Labor and management — industry as a whole — will come closer to solution than can be done by two approaches—one driven by labor, the other by management.

Something novel would come out of postwar planning if men could be enlightened to the extent of recognizing that there are no such elements as management and labor, but simply industry, which is management, labor and capital. The man drawing a weekly wage is a capitalist whether he likes the description or not. His wage will be influenced by the accomplishments of research, and a comprehensive program will explain research in that light.

Deductions for federal taxes should be convincing that the workman must bear his share of cost of government. There are numerous instances, the petroleum industry being one, to show how better merchandise at lower prices can be provided along with higher wages.

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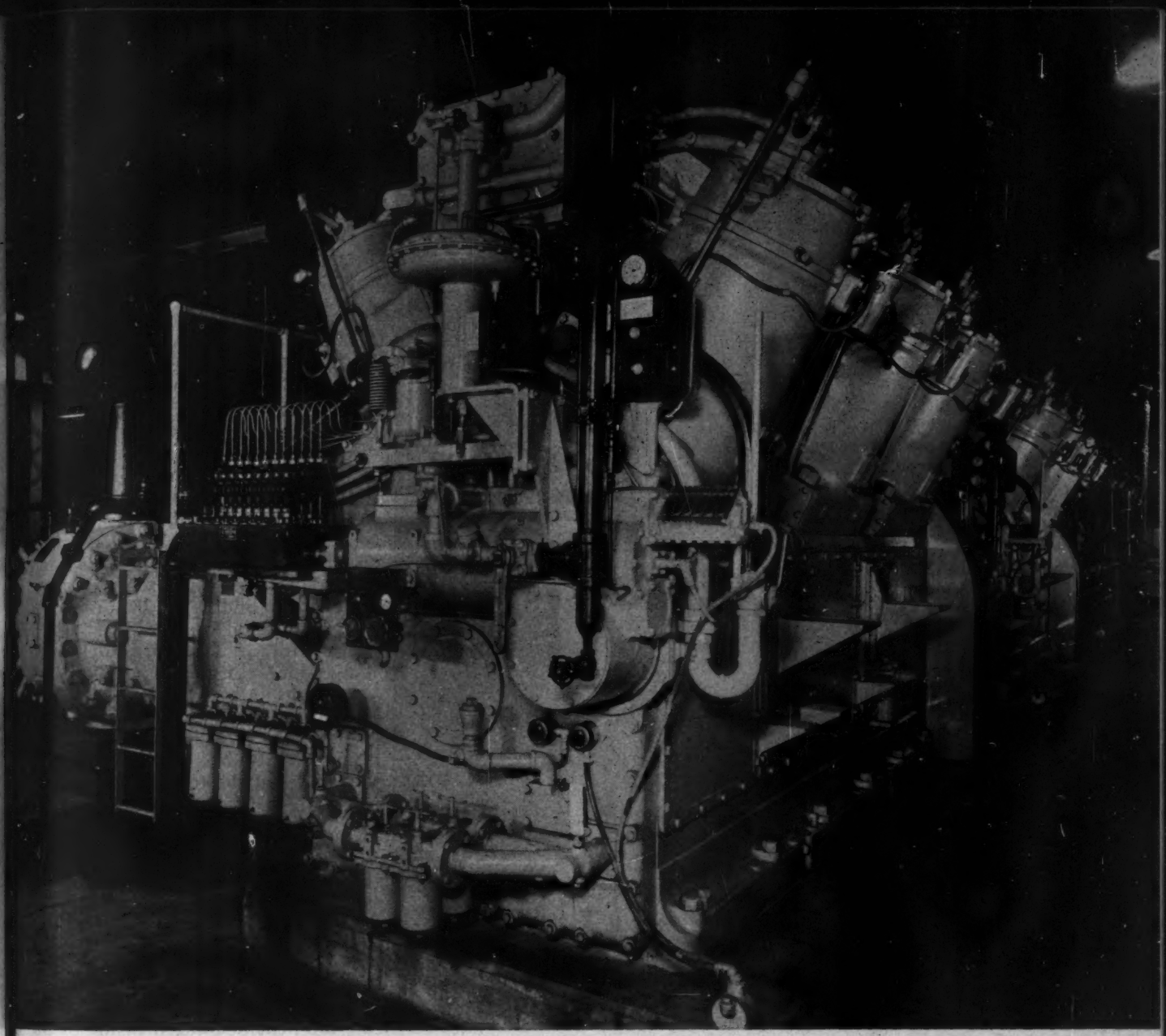


# Controlled Water Jacket Cooling Reduces Maintenance Costs

B. C. THIEL, Consulting Engineer
The Cooper-Bessemer Corporation

THE fact that an inadequate or unsuitable water supply for the cooling of internal combustion engines and gas-compressor cylinders has increased the maintenance cost of compressor stations much more than would be normally expected has been known to the builders of this equipment for many years, but until the past few years the operators were prone to disregard this fact. After one or two stations had been built and operated with the proper cooling system and the resulting decrease in maintenance was shown, the trend toward the proper design and operation of cooling systems was on its way. Many a piston seizure that was blamed on lack of lubrication was directly traceable to poor or improper

cooling-water conditions. In the past most compressor stations were built at the bank of a stream or near some source of water. Where water was plentiful it was pumped through the compressor jackets and wasted, but where wells were the source of water supply a cooling pond or tower was used and in this case the water was cooled and re-used, the only loss being evaporation and windage loss. Little thought was expended upon the incoming and outgoing water temperatures or the scale-forming constituents in the water unless they were particularly bothersome. But those days are over and the newer compressor stations are designed with an eye to the cooling-water situation, and in consequence the maintenance cost due to bad water conditions is rapidly being eliminated. Most stations of recent date use a closed cooling-water system that is charged with clean pure water. In systems of this kind the scale formation is practically nil and the temperature differential is controlled to within one degree plus or minus by automatic temperature controls.

Let us take up the causes that were instrumental in the change in cooling-water-system design, for surely the additional expenditure necessitated by the present system should be justified to the user. In the old system, during winter operation it was nothing unusual to have the water temperature at the engine inlet at 40° F. and the outlet at 140° F., a temperature differential of 100° F. and the temperature during summer operation was in the neighborhood of 70° F. in, and 140° F. out, a temperature differential of 70° F. In a horizontal engine where the cold water was generally distributed over the lower side of the water jacket and forced around the cylinder barrel toward an outlet at the top of the water jacket, this temperature differential had a tendency to bow the cylinder barrel as the top of the barrel became longer than the bottom because it was much hotter. Then during winter operation with a temperature differential of 100° F. the top of a liner 5 feet long would be .036 inch longer than the bottom and .025 inch longer during summer operation with a temperature differential of 70° F. This produced strains in the liner that tended to shorten its life and produced excessive and unproportional wear. In vertical cylinders the difference in diameter between the top and bottom of the cylinders is .011 inch for a differential of 100° F. and .007 inch for 70° F. for an 18-inch diameter cylinder. Cylinders operating under conditions of this kind must have excessive piston clearance in order to operate and necessarily be subject to piston slap when the temperature differential is lowered, which would cause excessive liner and piston wear. The above shows that with large temperature differentials we are faced with undue heat stresses and excessive piston wear, besides being in danger of piston seizure.

Now let us see what the effect of scale-forming cooling water will have upon compressor operation, bearing in mind that the function of the cooling water is to carry off the heat generated inside of the cylinder. The thermal conductivity of cast iron is 336 Btu per square foot of area per °F. of temperature difference per inch of thickness, and if we assume that ordinary hard scale has the same thermal conductivity of limestone which is 6.30 Btu per square foot per °F. per inch, then 1/16-inch-thick scale has the same thermal conductivity as 3-5/16-inch thickness of cast iron. Therefore, a cast-iron liner 1 inch thick covered with 1/16-inch thick scale will have the same thermal conductivity as a scale-free cast-iron liner 4-5/16 inches thick. Should the scale be porous on the order of pumice stone which has a thermal conductivity of 1.62 Btu per square foot per °F. per inch, then 1/16-inch thick scale has the same thermal conductivity as 13-15/16-inch thick cast-iron, or a 1-inch-thick cast-iron liner covered with 1/16-inch thick porous scale would have the same thermal conductivity of a scale-free cast-iron liner 14-15/16-inch thick. From this we can visualize the importance of having cooling water that contains no scale-forming compounds, for the purpose of the cooling water is defeated if scale is allowed to form on the outside of the cylinder liner. Then, too, when scale is allowed to form on the liner the temperatures indicated by the thermometers in the water jacket are erroneous. A thermometer reading of 120°F. in the jacket-water

outlet channel is no indication of the temperature of the cylinder liner itself if this liner is covered with scale, as the liner may be hot enough to carbonize the lubricating oil and cause excessive liner and ring wear even though the temperature of the cooling water is normal. The above examples should be conclusive evidence for small temperature differentials and pure clean cooling water.

When a plant that has used scale-forming water is to be changed over to one operating on treated water, the entire system should be cleaned of scale. This is most easily done by dividing the plant and its water piping into sections and circulating an acid solution containing inhibitors through each section until each section is thoroughly clean. The sections are then washed out with treated water before being reconnected and put into service.

The following is an analysis of water to be used in cooling engine and compressor cylinders:

Dissolved Oxygen—Preferably 0 but not over 0.05 cc per liter.
pH Value—Not less than 8.
Oil—None.
Suspended Solids—None.
Hardness—Calcium and magnesium sulfates, added, not over 15 ppm. Calcium and magnesium carbonates, added, not over 75 ppm.
Organic Matter—Not over 5 ppm.
Chloride—Not over 6 ppm in terms of chlorine.

Any make-up water should be of the same analysis. Muddy water, no matter how non-scaling it is, should never be used. Water of this nature should be first settled in settling basins and then filtered until all mud has been removed. It will pay plant operators good dividends if a competent water chemist is consulted and his recommendations followed.

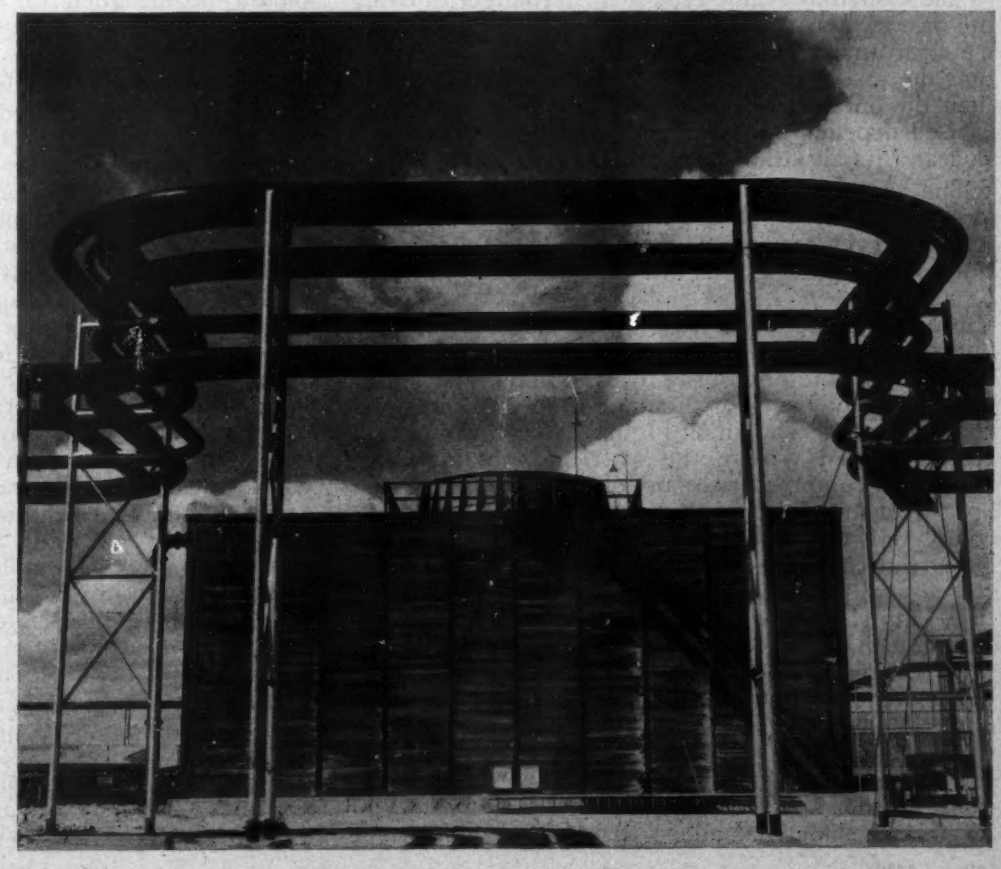
There are many kinds and types of water treatment. One of these is the zeolite process which removes the calcium and magnesium from scale-forming compounds and substitutes sodium in their stead. Most zeolite processes are fairly simple in operation and are adapted to automatic operation. The lime-soda process which converts the soluble calcium and magnesium bicarbonates to insoluble compounds that are precipitated and filtered out is somewhat more complicated and expensive in its operation than the zeolite process but it is also more efficient in its removal of scale-forming compounds. To prevent oxygen corrosion the cooling water is treated with potassium or sodium dichromate and a treatment with copper sulfate or chlorine will prevent the growth of algae.

An internal-combustion engine will consume in the neighborhood of 10,000 Btu per boiler-horsepower-hour, of which 2545 Btu is converted into useful work. The rest of the heat produced by the operating medium either gas or oil is rejected to the water jackets and to the exhaust. Of this 7455 Btu rejected approximately 40 percent or 2982 Btu is rejected in the exhaust leaving 4473 Btu to be dissipated by the cooling water. The above figures are approximate and in the calculation of pump sizes to take care of any specific installation the exact heat dissipation quantities should be obtained from the manufacturer of the equipment. The water-pump size can then be determined by equation.

$$\frac{(bhp)\ (H)}{500\ (\Delta t)} = gpm;$$

where bhp is the installed brake horsepower, H is the heat dissipated to the cooling water in Btu per bhp-hr, $\Delta t$ is the temperature differential in °F., or the temperature of the outgoing water minus the temperature of the incoming water °F. This equation is based on the cooling medium weighing 8.33 pounds per gallon and having a heat capacity of 1° F. per pound. For other mediums the constant of 500 must be revised. It is to be assumed that all calculations for cooling water are to be based on a closed system having a temperature differential of not more than 20°F. and preferably lower if the economics of the installation allow it. The reason for using a closed system can be shown by the following example.

Let us take a 1000-horsepower installation requiring a heat dissipation of 4500 Btu per boiler-horsepower-hour designated for a temperature differential of 15°F. This would necessitate the circulation of 600 gallons per minute. Roughly 1000 Btu are required to evaporate 1 pound of water, which is enough to cool 100 pounds of water 10°F., then for each 10°F. that the water is cooled 1 percent of the water is lost by evaporation. The normal windage or drift loss in a cooling tower is approximately 1 percent for the best of towers. In this case we cool the water 15°F. therefore the loss is 1.5 percent by evaporation and 1 percent by windage or drift or a



total of 2.5 percent. This is 15 gallons per minute or 21,600 gallons per day. Now if we are circulating a water having a hardness of 10 grains per gallon we will precipitate in the cooler pan or basin 216,000 grains per day or 30.86 pounds per day. If we assume this precipitate equal in weight to calcium carbonate ($CaCO_3 6H_2O$) which has a specific gravity of 1.771 we would precipitate .279 cubic feet per day. This would equal in volume 2.093 gallons per day and if we assume that the quantity of the water in the system is twice as much as is circulated or 1200 gallons, we will be adding .17 percent in the form of sludge or precipitate every day. From the above it can be seen that cooling water taken directly from the basin of an atmospheric cooling tower increases daily in sludge concentration which adds to the evils of scale formation produced by the natural hardness of the cooling water. Needless to say this type of a system is not recommended. Aside from the fact that this type of a system progressively increases its scale-forming qualities, another danger, oxygen concentration is present. When water is sprayed or falls through the air it absorbs air and with it oxygen, then as the temperature of the water is raised in the water jackets the oxygen is released and oxygen corrosion results. In a water jacket the constant scouring action of the fast-moving cooling water tends to scour off any oxide that would tend to form a protective coating and exposes new metal to the corroding action of the oxygen released. This is another reason for not using an open cooling system. Even though the water contains no scale-forming constituents, the purer the water the more oxygen-hungry it is, therefore, distilled water will cause greater oxygen corrosion than impure water.

There are two general methods of constructing a closed cooling system. One is to install tubes through which the treated cooling water is led near the bottom of an evaporative cooling tower and the other is to use a shell-and-tube-type heat exchanger, flowing the raw water through the tubes and the treated water around them. The reason for this procedure is that the inside of the tubes is more readily cleaned than the outside. The selection of whichever system is used depends upon the general layout of the station and its situation in regard to the water supply.

The systems now in use are shown in Figures 1 to 4, inclusive, which are more or less self-explanatory, however, a word or two in regard to the installations that these systems are best fitted for may not be amiss.

Figure 1 is a closed treated-water system using a hot well. This system is shown using cooling coils near the bottom of a spray ower, but the water may be cooled by using a shell-and-tube-type heat exchanger such as shown on Figure 3. This system generally is used where the station contains large horizontal compressors or any other compressors that are so constructed that the system cannot be made a completely closed one. In the large horizontal engines the cooling water for the power pistons and rods overflows into basins built into the bases of these units from where it flows by gravity to the drain lines. Various attempts have been made to make this portion of the cooling system on these units entirely enclosed but with dubious success. The main objection to the system shown on Figure 1 is the hot well. At this point the cooling water is prone to pick up oxygen, especially if the overflow lines of the units are not kept submerged by keeping the water level in the hot well above them. Then, too, if the top of the hot well is not completely covered, leaves, trash, and atmospheric dust will contaminate the cooling water. The effect of the absorbed oxygen can be checked by treating the water with sodium dichromate in a proportion of 1 pound for every 500 gallons in the system. Frequent checks should be made to be sure that this concentration is maintained and all make-up water should have the same concentration. This system is the best that can be installed for units having open overflow funnels that cannot be closed conveniently.

Figure 2 is a completely closed treated-water-cooling system using a standpipe and cooling coils near the bottom of a spray tower. This system generally is used where there is a shortage of water. In this system the raw water is used to cool the treated water and practically all of the make-up water is the raw water necessary to replace the evaporation and windage loss in the cooling tower. In locations of this nature it is best to use a good induced-draft tower so that the only losses are the evaporation losses. In order to maintain a constant temperature differential across the water jackets throughout the year a thermostatically operated by-pass valve is installed at a point where the by-pass around the cooling coils is connected to the delivery line from the cooling coils. This valve is controlled by the outlet temperature of the water jackets and operates in the following manner. Should the outlet temperature drop due to the fact that the incoming water is too cold the by-pass opens and allows a certain amount of the hot water drawn from the standpipe to by-pass the cooling coils and be injected into the stream entering the water jackets, thereby restoring the temperature differential in them. This system should be so designed that at no time the temperature of the water going to the water jackets from the cooling coils exceeds the inlet temperature for which the system is designed. In other words the system should be designed for the hottest day with the highest humidity for that particular location. Do not guess, be sure.

Figure 3 is a completely closed treated-water-cooling system using a standpipe and a heat exchanger instead of coils near the botom of the cooling tower. The raw water for the heat exchanger can come from the cooling tower or from a river or other supply of cold water. This system also contains a thermostatically operated valve used in the same manner as in Figure 2. It will be noted that the raw water is circulated through the tubes in the heat exchanger as they are more readily cleaned than the outside of the tube bundle. If the raw water is taken from a river or reservoir care must be exercised so as to be sure that no mud or silt is carried by the raw water. As an example of what can happen; some time ago the effluent of a sewage disposal plant, that was as clear as spring water to the eye, was used as a coolant. After a time it was noticed that the heat transfer was practically 50 percent of normal. The heat exchanger was opened and a deposit of cellulose was found in the tubes that had about the same heat transfer rate as celutex used for insulating buildings. This shows that a thorough test of the raw water should be made in all cases, and especially that used in a heat exchanger where its action is not visible as in open coils near the bottom of a cooling tower.

Figure 4 is a completely closed treated-water system using a standpipe and a heat exchanger. In this system, generally used where large quantities of raw

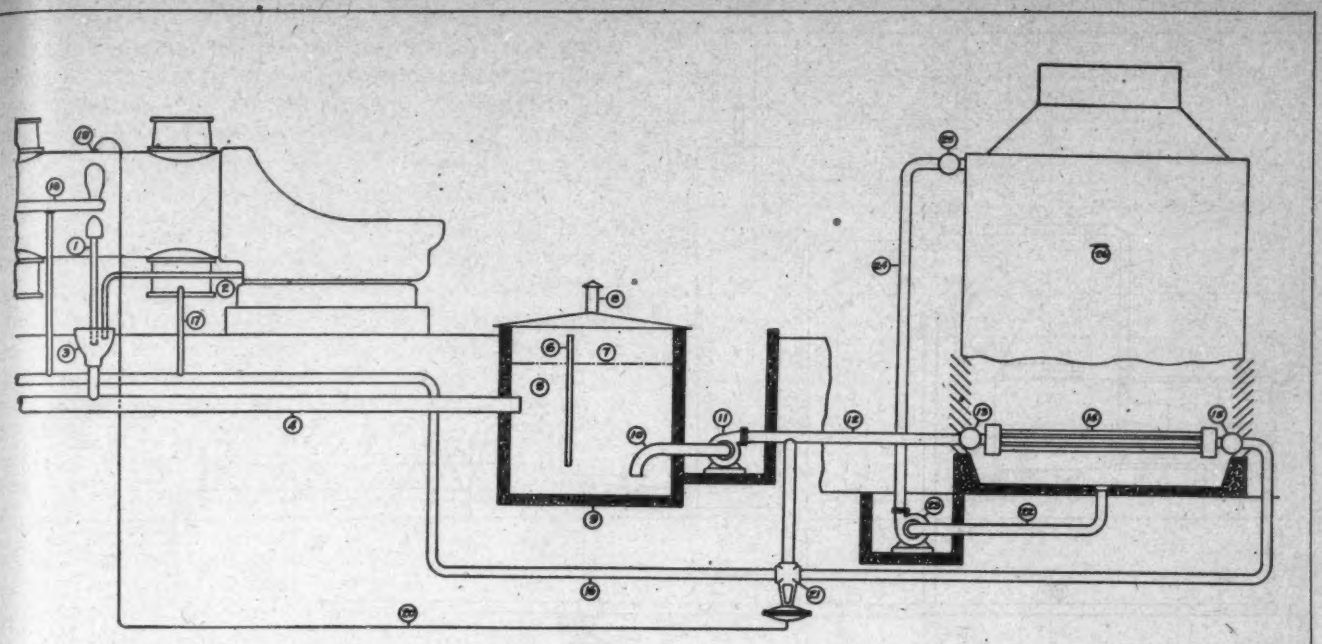


FIGURE 1

1. Power cylinder cooling water overflow.
2. Piston and piston rod cooling water overflow.
3. Overflow funnel.
4. Engine and compressor drain line.
5. Oil-skimming section in hot well.
6. Oil-skimming dam in hot well.
7. Water level.
8. Vent pipe in hot-well cover.
9. Hot well.
10. Treated-water pump suction.
11. Treated-water pump.
12. Treated-water pump discharge.
13. Cooling coil main inlet header.
14. Cooling coils.
15. Cooling coil main outlet header.
16. Cooled-water inlet header to engine and compressor
17. Inlet line to cylinder jackets.
18. Inlet to pistons and piston rods.
19. Thermostatic-control element.
20. Actuating line between control element and valve.
21. Thermostatically controlled three-way valve.
22. Raw-water suction line.
23. Raw-water pump.
24. Raw-water discharge line.
25. Spray-water distribution header.
26. Induced-draft tower.

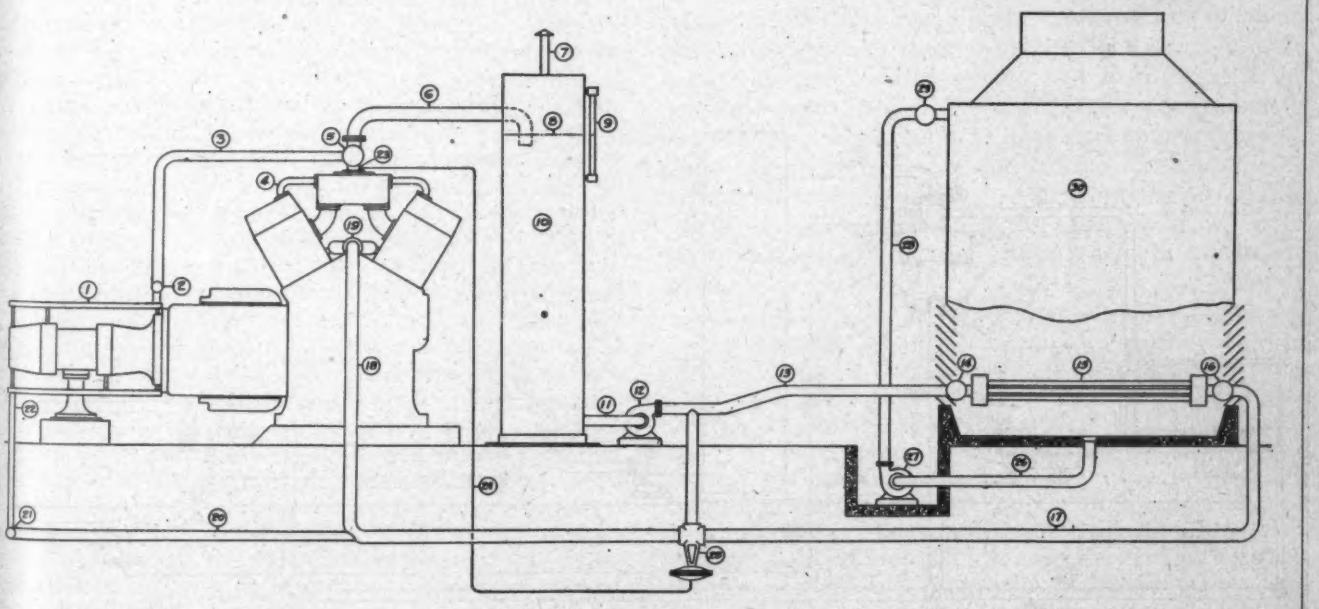


FIGURE 2

1. Individual compressor-cylinder outlet header.
2. Outlet header for all compressor cylinders.
3. Compressor-cylinder outlet line.
4. Individual engine-cylinder outlet headers.
5. Engine outlet header.
6. Engine and compressor-cylinder outlet line.
7. Standpipe vent line.
8. Water line.
9. Water-level gage.
10. Standpipe.
11. Treated-water pump suction line.
12. Treated-water pump.
13. Treated-water pump discharge line.
14. Cooling coil main inlet header.
15. Cooling coils.
16. Cooling coil main outlet header.
17. Inlet line to cylinder jackets.
18. Inlet line to engine jackets.
19. Engine inlet header.
20. Inlet line to compressor cylinders.
21. Inlet header for all compressor cylinders.
22. Individual compressor-cylinder inlet header.
23. Thermostatic-control element.
24. Actuating line between control element and valve.
25. Thermostatically controlled three-way valve.
26. Raw-water pump suction line.
27. Raw-water pump.
28. Raw-water pump discharge line.
29. Spray-water distribution header.
30. Induced-draft tower.

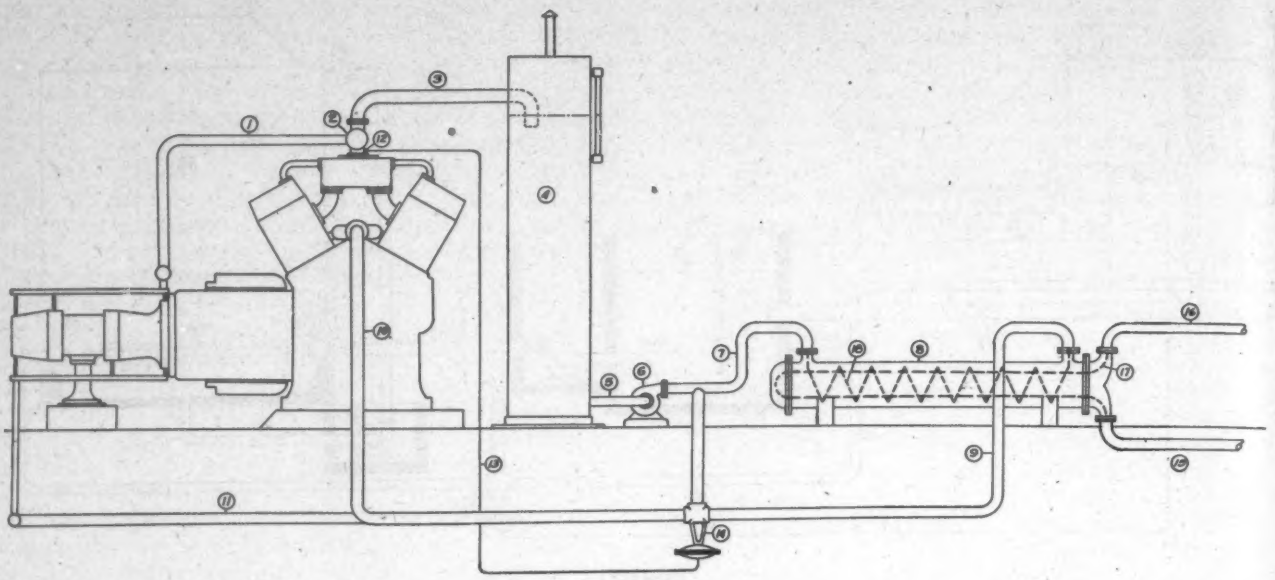


FIGURE 3

1. Compressor-cylinder outlet.
2. Engine-cylinder outlet.
3. Engine- and compressor-cylinder outlet line.
4. Standpipe.
5. Treated-water pump-suction line.
6. Treated-water pump.
7. Treated-water pump discharge line.
8. Heat exchanger.
9. Inlet line to cylinder jackets.
10. Inlet line to engine cylinder jackets.
11. Inlet line to compressor cylinder jackets.
12. Thermostatic-control element.
13. Actuating line between control element and valve.
14. Thermostatically controlled three-way valve.
15. Raw-water-inlet line.
16. Raw-water-outlet line.
17. Path of raw water in heat exchanger.
18. Path of treated water in heat exchanger.

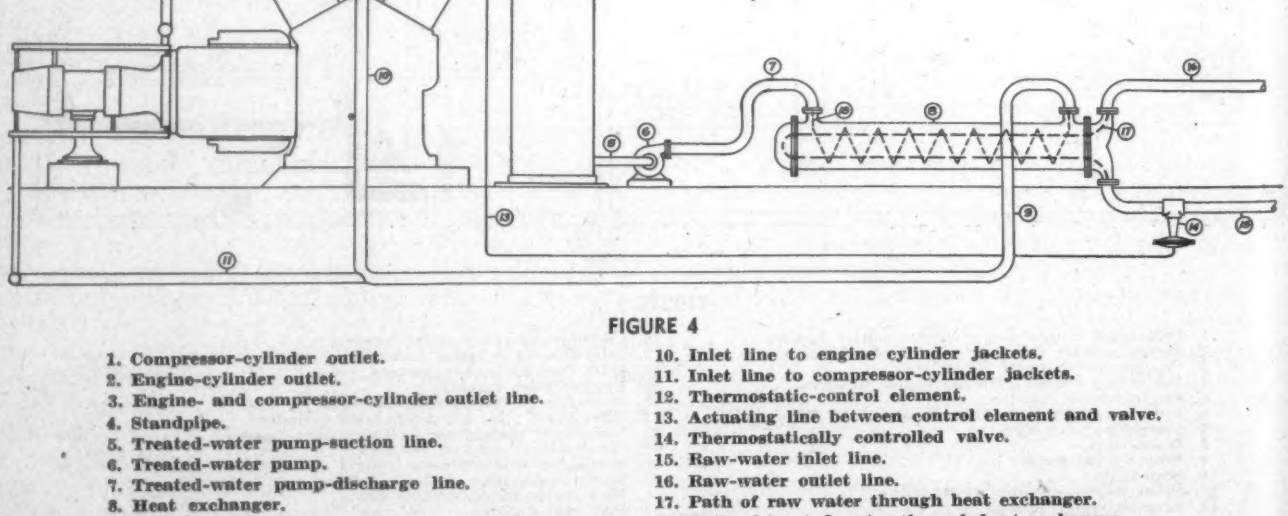


FIGURE 4

1. Compressor-cylinder outlet.
2. Engine-cylinder outlet.
3. Engine- and compressor-cylinder outlet line.
4. Standpipe.
5. Treated-water pump-suction line.
6. Treated-water pump.
7. Treated-water pump-discharge line.
8. Heat exchanger.
9. Inlet line to cylinder jackets.
10. Inlet line to engine cylinder jackets.
11. Inlet line to compressor-cylinder jackets.
12. Thermostatic-control element.
13. Actuating line between control element and valve.
14. Thermostatically controlled valve.
15. Raw-water inlet line.
16. Raw-water outlet line.
17. Path of raw water through heat exchanger.
18. Path of treated water through heat exchanger.

water are available, the temperature of the water going to the jackets is controlled by the amount of raw water that is fed to the heat exchanger. This system also may be used with a cooling tower as shown but the tower in this case must be designed for the maximum heat dissipation of the unit.

In localities where water is at a premium, radiators may be used instead of coils in the cooling water or heat exchangers. When radiators are used they should be equipped with adjustable louvres or shutters so that the temperature of the water leaving the radiators can be controlled. A by-pass may also be installed around the radiators in the same manner as in the preceding installations, but usually the temperature of the jacket water is controlled by opening and closing the louvres or shutters mentioned above.

The foregoing cooling systems are in their simplest forms. The actual systems are generally more complex especially so when the engines are equipped with oil-cooled pistons, and the heat exchangers for cooling the oil are coupled into the engine-cooling system. There are also a multitude of controls that can be installed in the cooling system that protect the engine from being damaged by high temperatures and loss of pressure in the cooling-water system. Each installation requires separate treatment based on the location, the availability of the water supply, and the economics of that particular installation. There is no one system that will completely fit all conditions.

In selecting water pumps for any installation it is well to bear in mind a few simple facts pertaining to the operation of centrifugal pumps. When selecting a centrifugal pump it is well to remember that the capacity of some types of pumps increases or decreases rapidly with a small change in head and as the actual operating head in most cooling systems cannot be calculated with exactitude it is best to select that pump that will give the smallest increase or decrease in capacity for the greatest change in head. Figures 5A and 5B show the head-capacity curves of two pumps, both of which will deliver 600 gallons per minute against a head of 60 feet, but the decrease in capacity for an increase in head of 5 feet is only 22 gallons per minute for the pump shown on 5A whereas it is 57 gallons per minute for the pump shown on 5B. Therefore the pump shown on 5A would be the correct pump to select because in a piping system as complicated as the cooling system for a compressor station an error of 5 feet head between the calculated head and the actual head is not out of reason. Although the efficiency of pump 5A is not quite as good as that of 5B at the desired head and capacity, the horsepower necessary to drive pump 5A is but very little greater than pump 5B, the additional horsepower, which is approximately 1.8 horsepower, is good insurance against finding oneself short of the desired quantity of water. Another thing to think of is that a centrifugal pump should be so installed that there is no suction lift. Although centrifugal pumps will operate with a suction lift, an installation of this type is liable to have the pump kick off if the least bit of vapor or air becomes entrained in the suction line to the pump. Therefore for continuous operation a centrifugal pump should always be installed with a position suction head.

The above notes are of a general nature and as stated before the principles embodied in them should

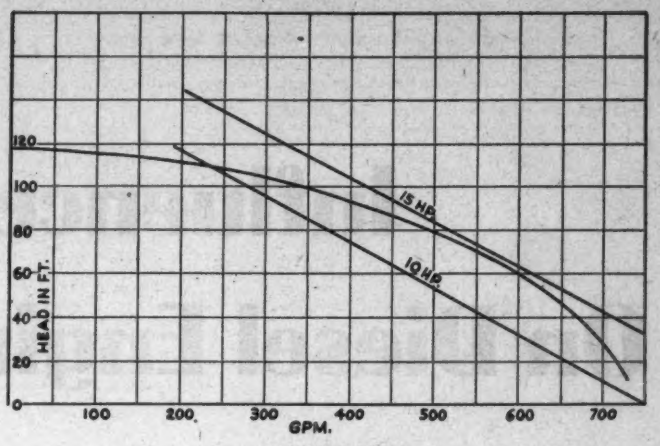


FIGURE 5A

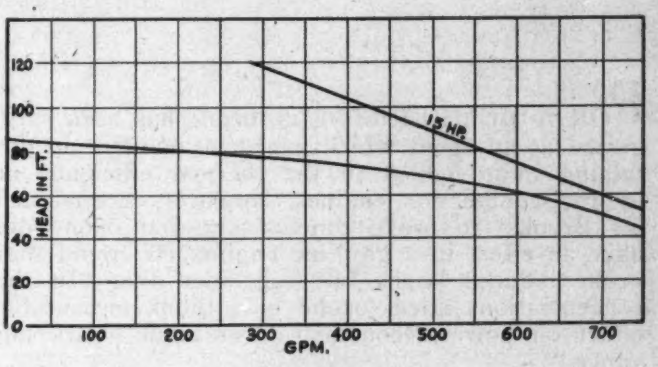


FIGURE 5B

be applied in any specific installation. The best way to proceed is to make a simple line layout of the cooling water system, noting thereon the pipe lengths and sizes, the various valves and fittings, and the pressure drop through any part of the equipment in the cooling system such as heat exchangers, cooling coils, engine and compressor jackets. By adding the various pressure losses the total pressure loss is quickly found and knowing the quantity of water to be circulated a tentative pump selection can be made.

A scaled layout can then be made and any interference with other station piping be checked and any additions or corrections can be noted and their effect upon the pressure losses noted. Always remember that the simplest piping system is the best, and that all water lines from the compressor to the standpipe should always have an upward slope. If this is a physical impossibility, the high points should be connected to the standpipe by bleeder lines that have an upward slope. This is to prevent any air or vapor pockets from interfering with the free flow of the cooling water. It is also an excellent idea to submit working drawings of the piping system to the manufacturer of the compressor for their consideration and advice. They maintain a staff of engineers who have had wide experience in the design of compressor stations and are always interested in seeing that their equipment is installed so that it will be capable of its best performance. When sending in layouts of this type all, and I mean all, of the data should be sent with them as this will save time and endless letter writing in order to give the engineers a complete picture of the customer's operating conditions.

# Influence of Ozone On Diesel Engine Performance

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Armour Research Foundation

FOR A NUMBER of years, ozone has been suggested as an agent which might be of value in obtaining improvement in the thermal efficiency of internal-combustion engines. However, it remained for Brooks[1] to prove conclusively that ozone did have an effect in a gasoline engine. He found that ozone induced knock but concluded that "In the concentrations tried, ozone is without measurable effect on power, economy, or optimum spark advance."

Both before and after the time of the above publication, ozonizers of various constructions have been patented for use on internal-combustion engines. In these patents, it is claimed that the introduction of ozone gives improved combustion with increased power output, promotes smoothness of operation, gives improved gas mileage, eliminates carbon monoxide, provides quicker starting and greater acceleration, and prevents formation of carbon on cylinder walls and pistons.[2, 3, 5, 6, 7]

In view of the widely conflicting statements concerning the use of ozone in internal-combustion engines, and with the present interest in conservation of fuels, it was the purpose of the experiments described in this paper to determine the influence of ozone on compression-ignition engine performance. Gasoline engines were not considered for these tests because the work of Brooks[1] had shown reliably that ozone had no practical effect on the power output or fuel consumption of such an engine.

## Experimental

A survey of the patent literature showed that ozone had been admitted into gasoline engines at four different places: the carburetor, the gas-air mixture leaving the carburetor, the fuel line, and the intake manifold. Obviously the first two points were automatically eliminated when considering diesel engines, and the third, admitting ozone into the fuel line, was discarded because of the difficulties involved.

Therefore, for one series of tests, ozone was admitted to the engine through the intake manifold.

Since ozone is decomposed by the temperature and pressure present in the cylinder during a compression stroke, any increase in engine efficiency due to the addition of ozone can be attributed only to the following:

1. Extra oxygen due to the breakdown of ozone.
2. Energy evolved during the decomposition of ozone.

This amount of oxygen and energy evolved during each cycle in an engine reasonably can be expected to be small because ozonizers of a size to be practical and economical for use on internal-combustion engines do not generate more than a few grams of ozone per hour. Therefore it was expected that ozonized fuel might influence engine efficiencies more than ozone admitted to the intake manifold. A second series of tests was made with fuel ozonized under various conditions.

*Apparatus*: Two engines were used for the experiments: both were single-cylinder test engines and both were coupled to induction-generater dynamometers to provide operation under full-load conditions and a means of measuring the power output. The engine used in testing the ozonized fuel was fitted with a window into the precombustion chamber so that a spectroscopic study could be made of the combustion process.[4] No. 3 fuel oil was used for the first series of tests.

Ozone was generated by a silent discharge machine shown in Figure 1 attached to the intake manifold of the engine. This unit was designed to develop and deliver one gram of ozone per hour when operated under the following conditions: 40 percent relative humidity, 118 volts, 60 cycles input voltage with a current drain of 15 milliamperes. The ozone output was determined by the method of Thorp[8] and was found to be 1.020 grams per hour at the maximum setting.

Air, supplied to the ozonizer from a small diaphragm-type compressor and dried with activated alumina, was metered by a wet-test gas meter.

*Procedure*:

*A. Introduction of Ozone into the Intake Manifold*

The ozonizer was set as shown in Figure 1 to feed ozone into the engine at a point between the manifold and the air cleaner. This was done to prevent decomposition of the ozone on the copper turnings in the filter pad.

Before making any tests, a warm-up period of 30 minutes was allowed for the ozonizer and the engine

to come to equilibrium. All tests were one hour long. During the preliminary runs, air was circulated through the ozone generator to forestall any change in the operation of the engine caused by the addition of air at another point in the intake.

Operating characteristics and exhaust analysis were recorded at regular intervals throughout each test period.

*B. Ozonization of Fuel Oil*

In order to determine engine performance with ozonized fuel, the following 4 one-half-gallon samples were prepared from No. 2 fuel oil.

1. Untreated oil.
2. Oil ozonized at room temperature for 2 hours, 1020 mg. ozone per hour.
3. Oil aerated at 150° F for 2 hours, no ozone.
4. Oil ozonized at 150° F for 2 hours, 1020 mg. ozone per hour.

A 5-liter flask, fitted with a reflux condenser, was used in the preparation of the above samples. Ozone or air was bubbled through the oil from a sintered diffusing tube.

These samples were run in the second test engine fitted with windows in the precombustion chamber. The fuel consumption was checked and a spectroscopic study was made of the combustion of each sample.

*Experimental Results:* Data from the first tests, the introduction of ozone into the manifold, are presented in Table 1. Table 2 contains the results of tests with ozonized fuel, while Table 3 shows the fuel-oil consumption calculated from the data of Table 2. A print of the spectrogram made during the study of flame characteristics is shown in Figure 2. Two exposures were made for each fuel, one of 5 minutes and the second of 30 minutes duration.

*Discussion:* An examination of the data fails to reveal any change in engine performance by the addition of ozone directly to the engine or to the fuel. Neither does the addition of ozone to the fuel cause any change in the combustion process. There were no new spectral lines shown by the spectrogram. The small differences in fuel consumption are well within the limits of experimental error. It is improbable that ozone causes any marked change in diesel-engine performance unless added in much larger quantities than those used for these experiments. However, the generation of ozone in appreciable amounts and high concentrations requires special drying, cooling, and generating equipment which would not be practical on a diesel engine. The ozonizer used for these experiments cost almost $100 for parts alone and sells for over $300. This fact alone would eliminate the use of ozone for most applications even if it did produce some increase in power output or a decrease in fuel consumption. In other words, the cost of the ozonizer must be offset by a saving in fuel.

The diesel engine function of compressing air to the ignition point of the fuel precludes the use of gaseous ozone because of the temperature developed

**TABLE 1**
**Influence of Ozone on Diesel Engine Performance**
(Ozone Introduced into Intake Manifold)

| | Test No. 1 | Test No. 2 | Test No. 3 | Test No. 4 |
|---|---|---|---|---|
| Total hours run | 1 | 1 | 1 | 1 |
| Average r.p.m. | 900 | 901 | 900 | 900 |
| Brake horsepower | 14.6 | 14.7 | 14.7 | 14.5 |
| Inlet water temperature, °F | 62 | 62 | 62 | 62 |
| Outlet water temperature, °F | 176 | 178 | 177 | 178 |
| Inlet air temperature, °F | 85 | 85 | 85 | 85 |
| Exhaust temperature, °F | 800 | 800 | 800 | 800 |
| Crank case oil temperature, °F | 140 | 140 | 140 | 140 |
| Lubricating oil pressure, p.s.i. | 30 | 30 | 30 | 30 |
| Fuel oil pressure, p.s.i. | 7 | 7 | 7 | 7 |
| Air-fuel ratio | 29.2 to 1 | 29.2 to 1 | 29.2 to 1 | 29.2 to 1 |
| Percent $O_2$ in exhaust | 10.5 | 10.6 | 10.4 | 10.5 |
| Percent $CO_2$ in exhaust | 7.8 | 7.7 | 7.6 | 7.8 |
| Ozone-air input, c.f.m. | 0.0 | 0.0 | 1.0 | 1.0 |
| Ozonizer setting, Ma. | 0.0 | 0.0 | 7.0 | 15.0 |
| Ozone input, Mg. per hour | 0.0 | 0.0 | 506 | 1020 |

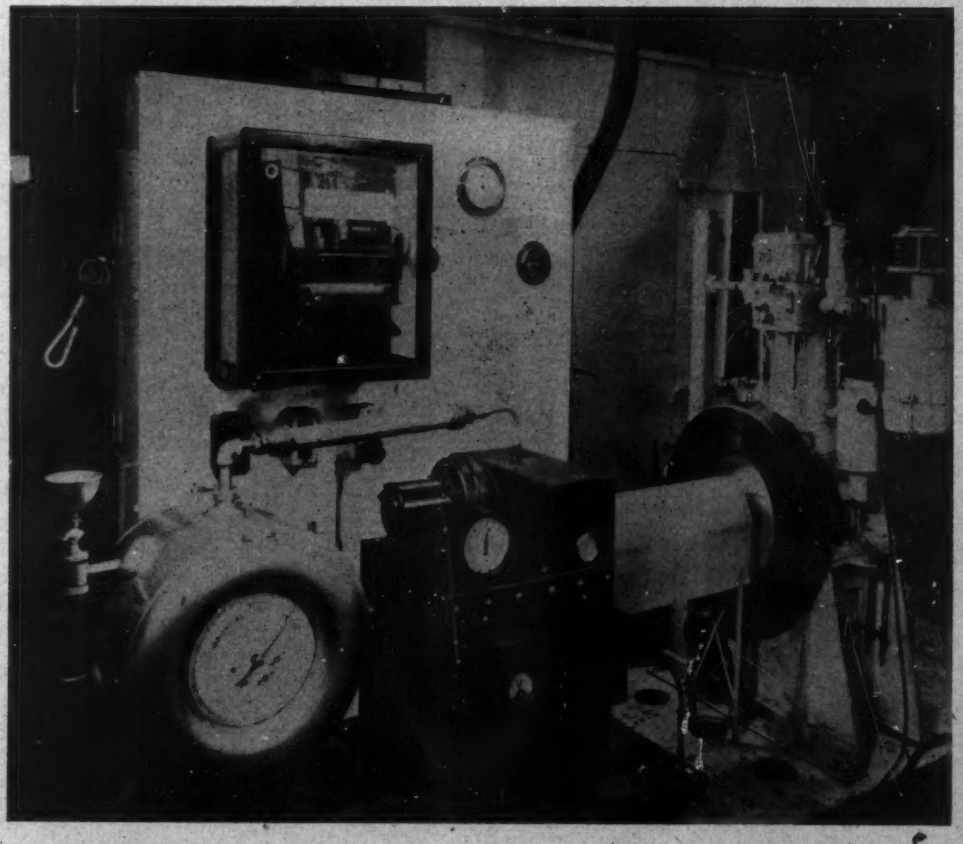

**FIGURE 1**
**Equipment used in determining the influence of ozone on diesel engine performance.**

FIGURE 2

Spectrogram of the combustion of various fuels in a diesel engine

A. Iron Arc Spectra
B. No. 3 oil, 5 minute exposure
C. No. 3 oil, 30 minute exposure
D. Oil ozonized at room temperature, 5 minute exposure
E. Oil ozonized at room temperature, 30 minute exposure
F. Oil ozonized at 150° F., 5 minute exposure
G. Oil ozonized at 150° F., 30 minute exposure
H. Oil aerated at 150° F., 5 minute exposure
I. Oil aerated at 150° F., 30 minute exposure

within the engine. Temperatures above 500° F. rapidly decompose ozone, whereas the temperature reached in a diesel engine on the compression stroke may be as high as 850° F.

Oxides of nitrogen have not been considered in this paper because the ozonizer used did not produce any nitrogen oxides. However, a large number of so-called ozonizers generate more oxides of nitrogen than ozone. It may be thought that the oxides of nitrogen are responsible for changes in engine performance but Brooks[1] found ozone alone was responsible for the increased knock in his tests with gasoline engine.

TABLE 2

Influence of Ozonized Fuel on Diesel Engine Performance

| Time P.M. | Ml. Fuel Added | Exhaust Temp. °F. | Cooling Water Output Temp. °F. | Power Output | | Speed r.p.m. |
|---|---|---|---|---|---|---|
| | | | | Amperes | Volts | |
| **Regular No. 3 Fuel Oil** | | | | | | |
| 2:10:25 | 100 | 550 | 178 | 17.0 | 113 | 1200 |
| 2:15:25 | 100 | 550 | .... | 17.5 | 113 | 1200 |
| 2:20:35 | 100 | 550 | .... | 17.4 | 113 | 1200 |
| 2:25:46 | 100 | 540 | 178 | 17.3 | 113 | 1200 |
| 2:31:00 | 100 | 540 | .... | 17.0 | 114 | 1200 |
| **Fuel Line Clogged for a Few Minutes** | | | | | | |
| 2:38:50 | 100 | 520 | .... | 17.0 | 114 | 1205 |
| 2:44:03 | 150 | 530 | 178 | 17.2 | 115 | 1205 |
| 2:51:50 | End | .... | .... | .... | .... | .... |
| **Oil Ozonized Two Hours at Room Temperature** | | | | | | |
| 2:54:15 | 100 | 540 | 178 | 17.5 | 116 | 1210 |
| 2:59:25 | 100 | 540 | .... | 17.5 | 116 | 1215 |
| 3:04:37 | 100 | 540 | .... | 17.5 | 116 | 1215 |
| 3:09:50 | 200 | 540 | .... | 17.6 | 115 | 1215 |
| 3:20:20 | 100 | 530 | .... | 17.8 | 114 | 1215 |
| 3:25:33 | 100 | 530 | 178 | 17.7 | 114 | 1220 |
| 3:30:48 | End | .... | .... | .... | .... | .... |
| **Oil Aerated at 150° F. for Two Hours** | | | | | | |
| 3:34:15 | 100 | 530 | 178 | 17.9 | 114 | 1225 |
| 3:39:15 | 100 | 530 | .... | 18.0 | 113 | 1225 |
| 3:44:12 | 200 | 530 | .... | 18.0 | 112 | 1225 |
| 3:54:07 | 200 | 530 | .... | 18.2 | 112 | 1225 |
| 4:04:05 | 200 | 530 | 178 | 18.0 | 114 | 1230 |
| 4:14:05 | End | .... | .... | .... | .... | .... |
| **Oil Ozonised at 150° F. for Two Hours** | | | | | | |
| 4:15:22 | 100 | 530 | 178 | 18.0 | 116 | 1230 |
| 4:20:34 | 200 | 540 | .... | 17.9 | 116 | 1230 |
| 4:31:00 | 300 | 540 | .... | 18.0 | 115 | 1230 |
| 4:43:00 | .... | 530 | .... | 18.0 | 114 | 1225 |
| 4:46:35 | 200 | 530 | .... | 18.0 | 114 | 1225 |
| 4:57:00 | End | .... | .... | .... | .... | .... |

TABLE 3

Consumption of Ozonized Fuels

| Sample | Length of Test. Seconds | Ml. Fuel Used | Fuel Consumption Ml. per Sec. | Fuel Consumption Gal. per Hr. |
|---|---|---|---|---|
| Regular No. 3 oil | 1235 | 400 | 0.324 | 0.31 |
| Oil Ozonized at Room Temperature | 2193 | 700 | 0.319 | 0.30 |
| Oil Aerated at 150° F | 2390 | 800 | 0.335 | 0.32 |
| Oil Ozonized at 150° F | 2498 | 800 | 0.324 | 0.31 |

## Conclusions

1. The addition of ozone to a diesel engine is without effect on power output or operating characteristics.

2. The ozonization of fuel oil likewise causes no change in fuel consumption or power output of an engine.

3. Ozone, introduced into the manifold, did not affect the analysis of the exhaust gases from the engine.

## Acknowledgment

The authors wish to express their appreciation to Dr. Ernest W. Landen for his aid in making the tests with the ozonized fuel oil. Special credit is due Mr. Norman C. Penfold, for his helpful suggestions and experimentation made possible the work described.

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# The Design of Ring Girders For Horizontal Tanks

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SINCE 1931, when Herman Schorer presented his paper "Design of Large Pipe Lines" (A.S.C.E. Transactions 1933) the question of supporting large horizontal pipe lines has been a subject of much controversy. In 1940 the Bureau of Reclamation published its Boulder Canyon Project final reports, "Penstock Analysis and Stiffener Design." This valuable publication reports Schorer's solution for supporting large horizontal pipe the nearest to a satisfactory solution.

This, however, left the question of supporting large horizontal vessels still unanswered. After two years' research the following analysis is presented.

The two rings at the supports, 90 degrees to the shell, provide an adequate moment of inertia to resist internal pressure and circumferential bending moment.

Another interesting point is the resultant longitudinal stresses. Longitudinal stresses have been neglected by many designers under the impression they were small. This, however, is not always true. An investigation of the three long stresses will reveal this. Once again the ring girder with its area of two complete rings to distribute the ring stresses proves of value. As only two ring girders are used, the cost of foundations prove to be an additional saving. The ring girders can be fabricated from bar stock, formed in angle rolls, thereby reducing fabrication costs.

## RING GIRDER DESIGN

The following analysis of stresses in the shell and stiffener is based on the Boulder Canyon Report. Bulletin No. 5, Part V. "Penstock Analysis and Stiffener Design."

### Nomenclature

| Symbols | | Units |
|---|---|---|
| A | Area of cross-section of stiffener ring | Sq. In. |
| $t_1$ | Thickness of web of stiffener ring | Inches |
| E | Modulus of elasticity of material | Lbs./sq. in. |
| I | Moment of inertia of cross-section of stiffener ring about its centroidal axis | Inches$^4$ |
| K | A constant | |
| L | Length of span supported by ring girder | Inches |
| f | Length of equivalent flange width on either side of web of stiffener ring $0.78\sqrt{rt}$ | |
| M | Tangential bending moment in stiffener ring, positive if tending to produce compression in the outer fibers | In. lbs. |
| p | Internal pressure | Lbs./sq. in. |
| B | A pipe shell constant $\sqrt[4]{\frac{3(1-u)}{r^2t^2}} = \frac{1.285}{\sqrt{rt}}$ | |
| Q | Combined weight of steel and water in span of length L | Lbs. |
| r | Radius of mean surface of shell inside Radius $+\frac{t}{2}$ | Inches |
| R | Radius of centroidal axis of cross-section of stiffener ring | Inches |
| S | Intensity of stress | Lbs./sq. in. |
| t | Thickness of shell | Inches |
| $\Theta$ | Angular co-ordinate | |
| T | Resultant tension in stiffener ring | Lbs. |
| u | Poisson's ratio | |
| $\overline{Z}$ | Distance from neutral axis of cross-section of stiffener ring to inside fiber | Inches |
| $\overline{X}$ | Distance from neutral axis of cross-section of stiffener ring to outside fiber | Inches |
| $Q_s$ | Weight of steel in one span of length L | Lbs. |

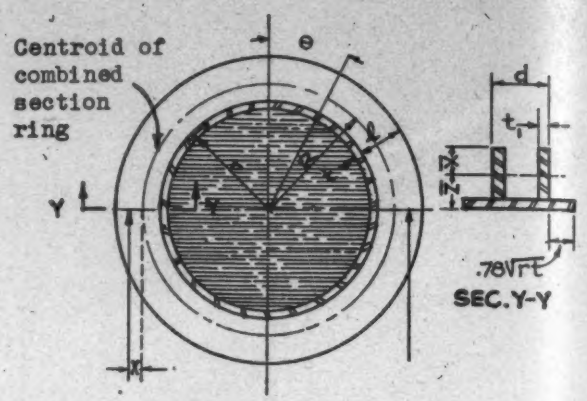



FIGURE 1

$$Z = \frac{r}{R}\left(1 - \frac{2K}{Br}\right) - \frac{X}{R}$$

$$B = \frac{1.285}{\sqrt{rt}}$$

$$K = \frac{r}{L}\left[\frac{uL^2}{12r^2} + (1-u^2)\left(1 - \frac{Qs}{2Q}\right) + \frac{(2+u)L}{4Br^3}\right]$$

u = Poisson's ratio = 0.3

$$C = \left(\frac{r}{R} - 1\right)\left(1 - \frac{2K}{Br}\right) - \frac{X}{R}$$

$$d - (2t_1) = 1.56\sqrt{rt} \text{ Max.}$$

$$N = Pr\left[d + \frac{2(1-u^2)}{B}\right]$$

A = Area combined ring section in sq. in. $= t(d + 1.56\sqrt{rt}) + 2lt_1$

$A_n$ = Area net ring section in sq. in. $= td + 2l\,t_1$

L = Length of one span in inches

M = Bending moment in the ring, in. lbs.

N = Tension due to internal pressure, on net section of ring, in lbs.

P = Pressure in lbs./sq. in.

$Q_s$ = Weight of steel in one span in lbs.

Q = Combined weight steel and water in one span, in lbs.

S = Direct stress in the ring exclusive of N, in lbs.

T = Radial shear stress in stiffener ring, in lbs.

$$\text{Total stress in outer fiber of ring} = \frac{T}{A} - M\frac{\overline{X}}{I} + \frac{N}{A}$$

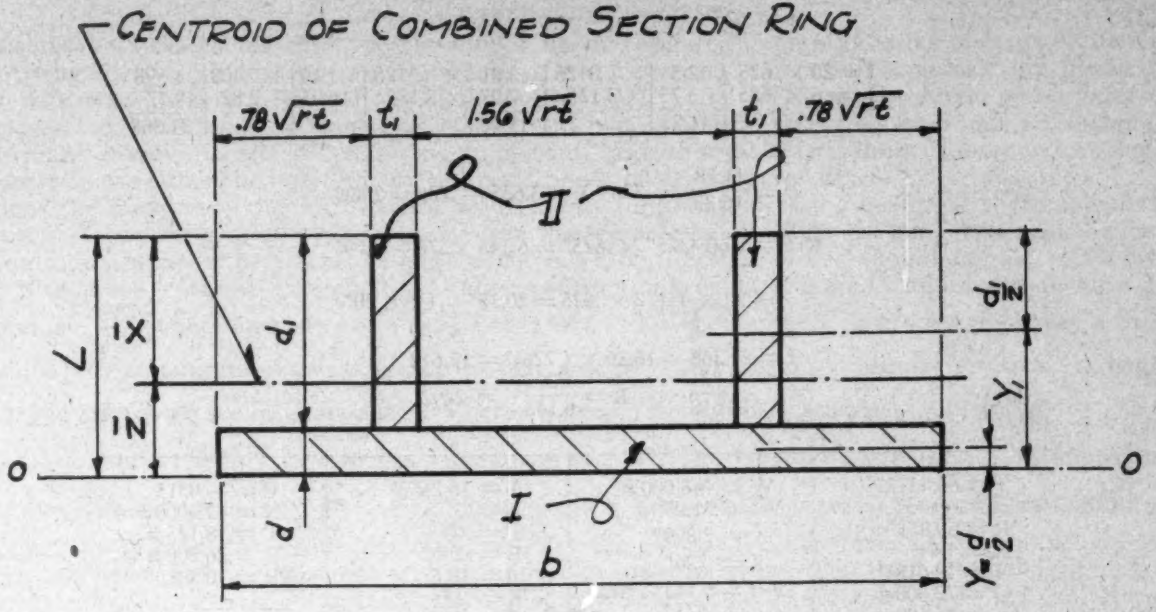
$$\text{Total stress in inner fiber of ring} = \frac{T}{A} + M\frac{\overline{Z}}{I} + \frac{N}{A}$$

| Θ° | $T = Q(K_1 + BK_2)$ | | $M = Q(RK_3 + XK_4)$ | | $S = Q(K_5 + CK_6)$ | |
|---|---|---|---|---|---|---|
| | $K_1$ | $K_2$ | $K_3$ | $K_4$ | $K_5$ | $K_6$ |
| 0° | −.238732 | +.318310 | +.011267 | −.068310 | 0 | 0 |
| 15° | −.241384 | +.307464 | +.008618 | −.057464 | +.019651 | +.082385 |
| 30° | −.248415 | +.275664 | +.001585 | −.025665 | +.032380 | +.159155 |
| 45° | −.257198 | +.225079 | −.007198 | +.024921 | +.032117 | +.225079 |
| 60° | −.263704 | +.159155 | −.013704 | +.090845 | +.014417 | +.275664 |
| 75° | −.263023 | +.082385 | −.013023 | +.167616 | −.022945 | +.307463 |
| 90°− | −.250000 | 0 | 0 | +.250000 | −.079577 | +.318310 |
| 90°+ | +.250000 | 0 | 0 | −.250000 | −.079577 | +.318310 |
| 105° | +.263023 | −.082385 | +.013023 | −.167616 | −.022945 | +.307463 |
| 120° | +.263704 | −.159155 | +.013704 | −.090845 | +.014417 | +.275664 |
| 135° | +.257198 | −.225079 | +.007198 | −.024921 | +.032117 | +.225079 |
| 150° | +.248415 | −.275664 | −.001585 | +.025665 | +.032380 | +.159155 |
| 165° | +.241384 | −.307464 | −.008618 | +.057464 | +.019651 | +.082385 |
| 180° | +.238732 | −.318310 | −.011267 | +.068310 | 0 | 0 |

+ = Tension  − = Compression.

Reference: "PENSTOCK Analysis and Stiffener Design," Boulder Canyon Project—Final Reports, Part 5, Bulletin 5.
Tables 3, 4 and 6.

Stiffener Ring Coefficients for Calculating Circumferential Stresses. The Example Gives an Illustration as to Its Use.




| MEMBER | A=Area In.² | AY In.³ | AY² | $I_o$ | $AY^2+I_o$ |
|---|---|---|---|---|---|
| I..... | b×d | A×Y | AY×Y | $I_{oI}$ | $AY^2+I_{oI}$ |
| II..... | $2t_1 \times d_1$ | A×$Y_1$ | $AY_1 \times Y_1$ | $I_{oII}$ | $AY^2+I_{oII}$ |
| | ΣA in.² | ΣAY in.³ | | | $\Sigma AY^2+I_o$ |

$$\overline{Z}=\frac{\Sigma AY}{\Sigma A} \qquad \overline{X}=L-\overline{Z}$$

$$I=\Sigma AY^2+I_o-\Sigma A(\overline{Z})^2$$

$$I_{oI}=\frac{bd^3}{12}$$

$$I_{oII}=\frac{t_1 d_1^3}{12}\times 2$$

$$I_o=I_{oI}+I_{oII}$$

**FIGURE 2**

**Procedure for Calculating Moment of Inertia of Ring Girder**

**Example of Ring Girder for 10'-0" I.D. x ¾" Wall (⅛" Corr) x 18'-0" T.L.ToT.L.**

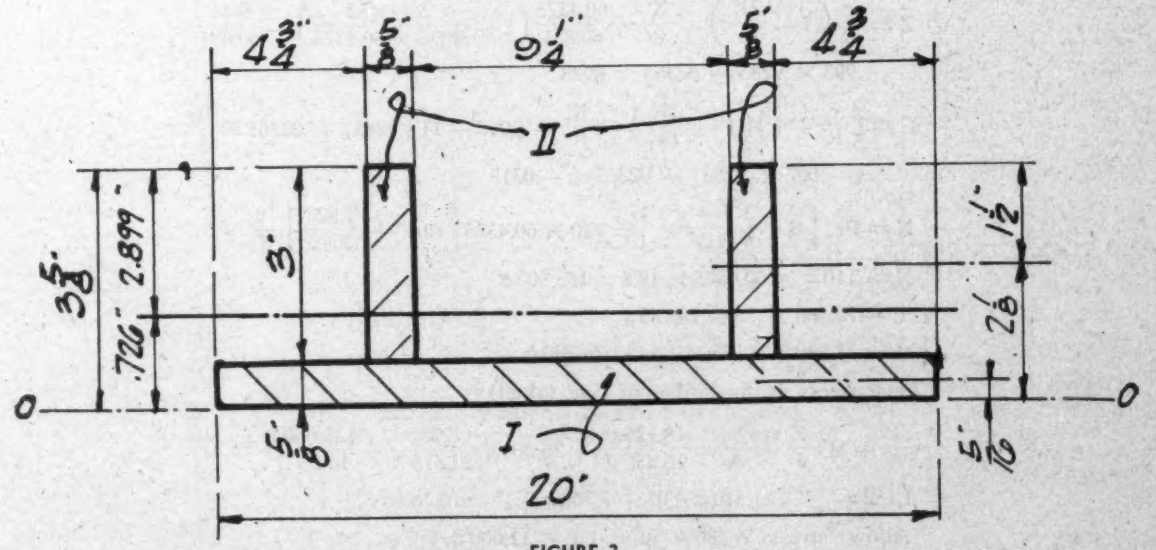



**FIGURE 3**

$$I_{o_I}=\frac{.625\times 3^3}{12}\times 2=2.82$$

$$I_{o_{II}}=\frac{20\times .625^3}{12}=.408$$

$r = 60.75''$ O.D. $- .3125'' = 60.4375''$

$t = .625$

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| I = 20 × .625 | 12.5 | × .3125 | 3.81 | × .3125 | 1.19 | + .408 | 1.598 |
| II = 6 × .625 | 3.75 | × 2.125 | 7.97 | × 2.125 | 16.95 | + 2.82 | 19.77 |
| | 16.25 | | 11.78 | | | | 21.368 |

$$\overline{Z} = \frac{11.78}{16.25} = .726'' \quad \overline{X} = 3.625 - .726 = 2.899$$

$$\sqrt{rt} = \sqrt{60.4375'' \times .625''} = 6.143 \times .78 = 4.79$$

$$4.79 \times 4 + 2 \times .625 = 20.35'' \quad \text{USE } 20''$$

$$I = 21.368 - 16.25 \times (.726)^2 = 12.618''^4$$

$$\frac{8.75}{12.618} \qquad B = \frac{1.285}{6.143} = .2092$$

| | | | |
|---|---|---|---|
| $r = 60.4375''$ | $W = 145{,}000\#$ | $A = 16.25\square''$ | $C = -.0315$ |
| $r_1 = 60.75''$ | $W_s = 31{,}000\#$ | $u = .3$ | $N = 125{,}000\#$ |
| $R = 60.851''$ | $\overline{X} = 2.899''$ | $u^2 = .09$ | $T = 18{,}125\#$ |
| $X = 1.44''$ | $\overline{Z} = .726''$ | $B = .2092$ | $M = 26{,}200\#$ |
| $I = 12.618''^4$ | $\sqrt{rt} = 6.143''$ | $d = 10.5$ | $AR = 10.30\square''$ |
| $Q = 72{,}500\#$ | $t = .625''$ | $K = .452$ | |
| $Q_s = 15{,}500\#$ | $P = 110\#/\square''$ | $Z = .8978$ | |
| $L = 141''$ | $c = .125''$ | | |

See Figure 1

$$R = 60.125'' + .726 = 60.851 \quad r_1 = 60.75''$$

$$L = \frac{282}{2} = 141'' \quad Q = \frac{W}{2} = \frac{145{,}000}{2} = 72{,}500\#$$

$$Q_s = \frac{W_s}{2} = \frac{31{,}000}{2} = 15{,}500\# \quad X = 62.25'' - 60.81 = 1.44''$$

$$K = \frac{r}{L}\left[\frac{uL^2}{12r^2} + (1-u^3)\left(1 - \frac{Q_s}{2Q}\right) + \frac{(2+u)L}{4Br^2}\right] =$$

$$\frac{60.4375}{141''}\left[\frac{.3 \times 19881}{12 \times 3653} + (.91 \times .893) + \frac{324}{4 \times .2092 \times 3653}\right] =$$

$$.428\ [.136 + .813 + .106] = .428 \times 1.055 = .452$$

$$Z = \frac{r}{R}\left(1 - \frac{2K}{Br}\right) - \frac{X}{R} = \frac{60.4375}{60.851}\left(1 - \frac{2 \times .452}{.2092 \times 60.4375}\right) - \frac{1.44}{60.851} =$$

$$.993 \times .9283 - .02365 = .8978$$

$$C = \left(\frac{r}{R} - 1\right)\left(1 - \frac{2K}{Br}\right) - \frac{X}{R} = (.993 - 1)\ (.9283) - .02365 =$$

$$(-.007 \times .9283) - .02365 = -.0315$$

$$N = Pr\left[d + \frac{2(1-u^2)}{B}\right] = 110 \times 60.4375\left[10.5'' + \frac{1.82}{.2092}\right] =$$

$$N = 110\# \times 60.4375 \times 18.8 = 125{,}000\#$$

$$T = 72{,}500 \times .25 = 18{,}125\#$$

$$M = 72{,}500\# \times .25 \times 1.44 = 26{,}200\#$$

Total stress in inner fiber of ring (shell) =

$$\frac{T}{A} + M\frac{\overline{Z}}{I} + \frac{N}{A} = \frac{18{,}125\#}{16.25\square''} + 26{,}200\#\frac{.726''}{12.618''^4} + \frac{125{,}000\#}{16.25\square''} =$$

$$1{,}150\#/\square'' + 1{,}510\#/\square'' + 7{,}700\#/\square'' = 10{,}360\#/\square''$$

Allow. stress W/80% joint eff. $= 11{,}000\#/\square''$

Radial stress in stiffener ring =

$$Q\ (K_s + CK_4) = 72{,}500\#\ [-.079577 + (-.0315 \times .31831)] =$$

$$72{,}500\# \times -.0903 = 6{,}750\#$$

$$\frac{S}{AR} = \frac{6750\#}{10.30\square''} = 655\#/\square'' \qquad \text{Allow} = 13{,}000\#/\square''$$

## Longitudinal Stresses

Membrane stresses for thin vessels should be investigated in storage tanks of large diameters and great lengths. I have covered the transverse or hoop stresses with an economical ring girder design that will meet paragraph W-325 (6) of the API-ASME Code. I have used the test weights for design purposes but I feel sure that operating conditions would suffice. The test conditions are of temporary nature and involve localized stress that would still be within the elastic limit. It is, therefore, up to the designer to use either the operating or test conditions for design purposes.

Since the membrane theory does not hold true at the juncture of the head and shell, and these discontinuity stresses may exceed the membrane theory, we should locate the support where the localized discontinuity stress is negligent. Therefore, the edge of the ring girder should not be located nearer than x distance from the Tangent line. Tables of functions of $B_x$ Figure 7 appearing in this article. B equals $\frac{1.285}{\sqrt{rt}}$ where r equals mean radius of tank and t is its thickness (corroded thickness if corrosion is added), by solving for x we can locate the ring girders where the discontinuity stresses are negligent. From the tables, we see $S_x$ is maximum where $B_x$ equals .7854 and $S_x$ equals $\frac{r\ p}{2\ t}\left[1 \text{ plus} \frac{6}{\sqrt{3(1-u^2)}} z\ (B_x)\right]$. $(S_x)_{max.}$ equals 2.172 $\frac{r\ p}{2\ t}$. From the tables, we can also see where $B_x$ equals 6, $S_x$ is approximately $\frac{r\ p}{2\ t}$. Since the stress induced by the rings and regular beam stresses are superposed, we should locate the rings away from the head discontinuity stresses. Of equal importance, they should be located where the beam bending moment at the support is equal to or less than the beam bending moment at the center. We can get the formulae from Singleton's "Manual of Structural Design"; Beam Formulae, overhanging both supports. The proposed ring girder design will not only prove economical but will meet paragraph W-305 (6) API-ASME Code.

### Longitudinal Stresses

Due to Internal Pressure

$S_x$ equals $\frac{r\ p}{2\ t}$

Due to Head Discontinuity Stress

Hemispherical Heads $S_x$ equals $\frac{r\ p}{2\ t}\left[1 \text{ plus} \frac{3}{2\sqrt{3(1-u^2)}}\ z(B_x)\right]$. $(S_x)_{max}$ equals 1.032 $\frac{r\ p}{2\ t}$

2:1 Ratio Elliptical Heads $S_x$ equals $\frac{r\ p}{2\ t}\left[1 \text{ plus} \frac{6}{\sqrt{3(1-u^2)}}\ z\ (B_x)\right]$. $(S_x)_{max}$ equals 2.172 $\frac{r\ p}{2\ t}$

See Figure 4.

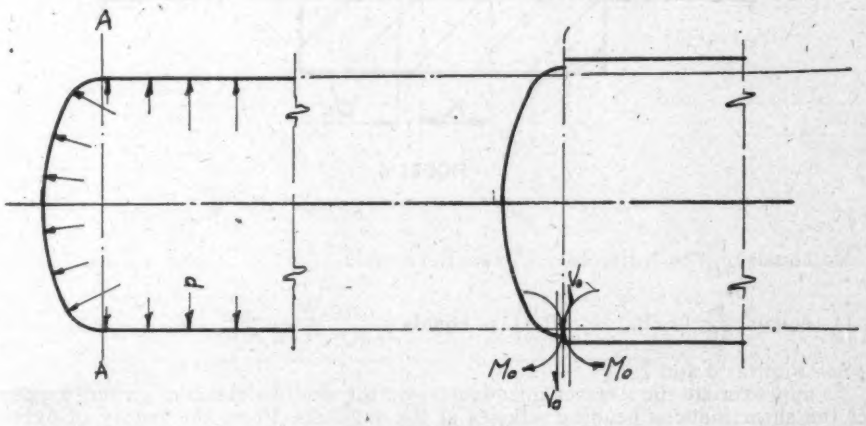



FIGURE 4

### Bending Moments Due to Beam Action

Cylinder, Simply Supported Beam Overhanging Both Supports

M equals $\frac{W(l-2a)}{8}$ at center $S_{x1}$ equals $\frac{Mc}{I}$

M equals $\frac{Wa^2}{2(l+2a)}$ at supports

M equals $\frac{W}{2(l+2a)}(a-x)^2$ at x, when $x < a$

M equals $\frac{W}{2(l+2a)}(a+x_1)^2 - Rx_1$ at $x_1$, when $x_1 < l$. R equals $\frac{W}{2}$

See Figure 5

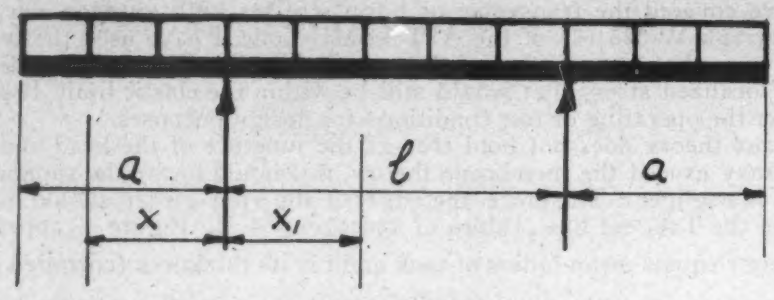



FIGURE 5
Simply supported beam overhanging both supports

Local Longitudinal Bending Induced by the Rings.
General Equations

$$W = \frac{e^{-B_x}}{2\,B_x}\,Mo\,(Sin.\,Bx - cos.\,Bx) - Qo\,Cos.\,Bx$$

$$Mo = \frac{P}{4\,B},\ P = 4BMx \text{ for } x = 0$$

The solution for a load distributed over the arc of contact can be found by superposition, from the solution for a concentrated load. This equation can be used for ring or saddle. The equation was set up so a comparison could be made.

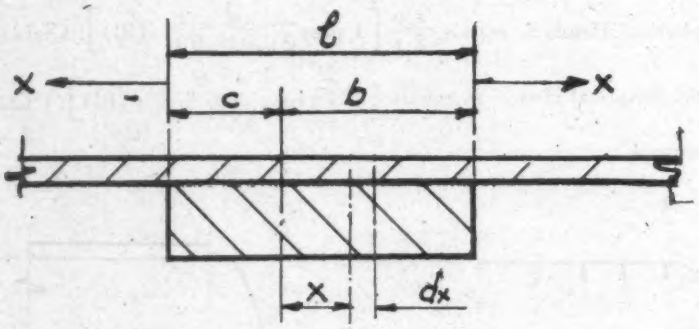



FIGURE 6

$M_x$ equals $\frac{p_1}{4B^2}(e^{-B_b}\sin.\,B_b + e^{-B_c}\sin B_c)$ equals

$M_x$ equals $\frac{p_1}{4B^2}[z\,(B_b) + z(B_c)]$. $p_1$ equals $\frac{W}{r_1 \times \alpha \times 2t_1 \times n}$

See Figures 6 and 7.

To approximate the stresses introduced into the shell by the ring girder, we can consider the shear induced bending stresses at the supports. From the theory of cylindrical shells, we can write the following differential equation:

$d^4y/dx^4$ plus $4B^4y$ equals 0 (1)

where

y equals Deflection of the shell in a radial direction.

x equals Distance measured parallel to the axis of the cylinder.

$B^4$ equals $3(1-u^2)/r^2t^2$ (2)

u equals Poisson's Ratio.

This is the same equation as is obtained for a beam supported by a continuous elastic foundation. The general solution of this differential equation is:

y equals $e^{Bx}(C_1 \cos Bx + C_2 \sin Bx) + e^{-Bx}(C_3 \cos Bx + C_4 \sin Bx)$ (3)

in which $C_1$, $C_2$, $C_3$ and $C_4$ are constants of integration and must be determined by the boundary conditions.

Since y equals o at x equals infinity

$C_1$ equals $C_2$ equals 0

Consider a long cylinder with a uniform radial force P per unit length of circumference dsitributed around the line of intersection of the cylinder with a plane perpendicular to the axis of the cylinder. This force will cause the cylinder to deflect radially intro-

ducing a shear and a bending moment. This deflection is given by Equation 3 where x is the distance measured from the plane of the force P. If this force is a long way from the ends of the cylinder the deflection will be symmetrical on both sides of the applied force P.

Also, at x equals 0, dy/dx equals 0

Let:

$M_o$ equal the bending moment at x equals 0.

$Q_o$ equals the shear force per unit of circumference at x equals 0.

Therefore:

$Q_o$ equals P/2

| Bx | z(Bx) |
|---|---|
| 0 | 0 |
| 0.1 | 0.0903 |
| 0.2 | 0.1627 |
| 0.3 | 0.2189 |
| 0.4 | 0.2610 |
| 0.5 | 0.2908 |
| 0.6 | 0.3099 |
| 0.7 | 0.3199 |
| 0.8 | 0.3223 |
| 0.9 | 0.3185 |
| 1.0 | 0.3096 |
| 1.1 | 0.2967 |
| 1.2 | 0.2807 |
| 1.3 | 0.2626 |
| 1.4 | 0.2430 |
| 1.5 | 0.2226 |
| 1.6 | 0.2018 |
| 1.7 | 0.1812 |
| 1.8 | 0.1610 |
| 1.9 | 0.1415 |
| 2.0 | 0.1230 |
| 2.1 | 0.1057 |
| 2.2 | 0.0895 |
| 2.3 | 0.0748 |
| 2.4 | 0.0613 |
| 2.5 | 0.0492 |
| 2.6 | 0.0383 |
| 2.7 | 0.0287 |
| 2.8 | 0.0204 |
| 2.9 | 0.0132 |
| 3.0 | 0.0071 |
| 3.1 | 0.0019 |
| 3.2 | —0.0024 |
| 3.3 | —0.0058 |
| 3.4 | —0.0085 |
| 3.5 | —0.0106 |
| 3.6 | —0.0121 |
| 3.7 | —0.0131 |
| 3.8 | —0.0137 |
| 3.9 | —0.0140 |
| 4.0 | —0.0139 |
| 4.1 | —0.0136 |
| 4.2 | —0.0131 |
| 4.3 | —0.0125 |
| 4.4 | —0.0117 |
| 4.5 | —0.0108 |
| 4.6 | —0.0100 |
| 4.7 | —0.0091 |
| 4.8 | —0.0082 |
| 4.9 | —0.0073 |
| 5.0 | —0.0065 |
| 5.1 | —0.0057 |
| 5.2 | —0.0049 |
| 5.3 | —0.0042 |
| 5.4 | —0.0035 |
| 5.5 | —0.0029 |
| 5.6 | —0.0023 |
| 5.7 | —0.0018 |
| 5.8 | —0.0014 |
| 5.9 | —0.0010 |
| 6.0 | —0.0007 |
| 6.1 | —0.0004 |
| 6.2 | —0.0002 |
| 6.3 | 0.0001 |
| 6.4 | 0.0003 |
| 6.5 | 0.0004 |
| 6.6 | 0.0005 |
| 6.7 | 0.0006 |
| 6.8 | 0.0006 |
| 6.9 | 0.0006 |
| 7.0 | 0.0006 |

**Functions of Bx**

$$B = \frac{1.285}{\sqrt{rt}}$$

x = Distance measured along longitudinal axis

z(Bx) = Function used in discontinuity longitudinal bending of shell and longitudinal bending at ring girders.

From Timoshenko's theory of plate and shell.

**FIGURE 7**

From the theory of Elasticity we have,

$$M_x \text{ equals } \frac{Et^3}{12(1-u^2)} \quad \frac{d^2y}{dx^2} \tag{4}$$

and

$$Q_x \text{ equals } \frac{dM_x}{dx} \text{ equals } \frac{Et^3}{12(1-u^2)} \frac{d^3y}{dx^3} \tag{5}$$

Where

$M_x$ is the bending moment at any point x.

$Q_x$ is the shear force at any point x.

Using the boundary conditions

x equals 0 and dy/dx equals 0

and differentiating Equation 3, we have,

$$dy/dx \text{ equals } -Be^{-Bx}(C_3 \cos Bx + C_4 \sin Bx) \quad e^{-Bx}(C_4 B \cos Bx - C_3 B \sin Bx) \tag{6}$$

Therefore

$o \text{ equals } BC_4 - BC_3$

or

$C_4 \text{ equals } C_3$

Using the relations in Equations 4 and 5, we find

$C_3 \text{ equals } -(1/2B^3D)(Q_o + BM_o)$ (7)

$C_4 \text{ equals } M_o/2BD$ (8)

where

$D \text{ equals } Et^3/12(1-u^2)$

Equating Equations 7 and 8 we get

$-(1/2B^3D)(Q_o + BM_o) \text{ equals } M_o/2B^3D$

or

$M_o \text{ equals } -Q_o/2B$ (9)

The relationship of the stress to the bending moment is,

$$S_{x3} \text{ equals } \frac{M_o \frac{t}{2}}{\frac{t^3}{12}} \text{ equals } \frac{6M_o}{t^2} \text{ Max.} \tag{10}$$

$$S_{x3} \text{ equals } \frac{6Mx}{t_2}$$

$\Sigma S_x \text{ equals } S_x + S_{x1} + S_{x2}$

$\Sigma S_x$ Allowable under API-ASME Code equals 13,750 lbs./sq.in.

EXAMPLE:

**Longitudinal Stresses**

$$\text{Internal Press.} = Sx = \frac{rp}{2t} = \frac{60.4375 \times 10\#/\square''}{2 \times .625\#/\square''} = 5300\#/\square''$$

Discontinuity Stress for 2:1 Ratio Elliptical Heads.

$$(Sx) \text{ Max} = 2.172 \frac{rp}{2t} = 11{,}500\#/\square'' \text{ at } Bx = .7854$$

$$x = \frac{.7854}{.2092} = 3.76'' \qquad \text{See Fig. 4, 7 \& 9}$$

$$Sx = \frac{rp}{2t}\left\{1 + \sqrt{\frac{6}{3(1-u^2)}}\, z(Bx)\right\} \quad \sqrt{\frac{6}{3(1-u^2)}} = \frac{6}{1.653} = 3.625$$

| x | Bx | z(Bx) | $1 + \sqrt{\frac{6}{3(1-u^2)}}\, z(Bx)$ | Sx |
|---|---|---|---|---|
| ..... | ..... | ..... | ..... | 5,300 lbs./□″ |
| 3.76 | .7854 | .3235 | 2.172 | 11,500 lbs./□″ |
| 5 | 1.0475 | .3035 | 2.1105 | 11,200 lbs./□″ |
| 6 | 1.259 | .2700 | 1.978 | 10,500 lbs./□″ |
| 8 | 1.68 | .1853 | 1.672 | 8,870 lbs./□″ |
| 10 | 2.095 | .1066 | 1.386 | 7,350 lbs./□″ |
| 15 | 3.140 | .00015 | 1.0005 | 5,300 lbs./□″ |
| 20 | 4.19 | —.0132 | 1.048 | 5,550 lbs./□″ |
| 25 | 5.24 | —.0046 | 1.01665 | 5,380 lbs./□″ |
| 30 | 6.275 | .0000 | 1. | 5,300 lbs./□″ |

**Bending Moment**

Simply Supported Beam Overhanging Both Supports—See Figure 5.

(1) $M = W\left(\frac{l-2a}{8}\right)$ at center

$a = 50''$
$l = 182''$
$W = .145 \times 10^6$

(2) $M = \frac{Wa^2}{2(l+2a)}$ at supports

(3) $M = \frac{W}{2(l+2a)}(a-x)^2$ at x, when $x < a$

(4) $M = \frac{W}{2(l+2a)}(a+x_1)^2 - Rx_1$ at $x_1$, when $x_1 < l$

See Figure 5.

Solve for (1) & (2) for $x = 5''$, $x = 10''$, $x = 16.24''$, $x = 20''$, $x_1 = 5$ & $x_1 = 10''$

(1) $= M = \frac{145{,}000 \times 82''}{8} = 1.49 \times 10^6$ $\quad x = 5''$, $M = \frac{145{,}000}{564}(50'' - 5)^2 = .52 \times 10^6$

(2) $= M = \frac{145{,}000 \times 2500}{564} = .64 \times 10^6$ $\quad x = 10''$, $M = \frac{145{,}000}{564}(50'' - 10'')^2 = .41 \times 10^6$

$x = 20''$ $M = \frac{145{,}000}{564}(50'' - 20)^2 = .232 \times 10^6$ $\quad x = 16.24''$, $M = \frac{145{,}000}{564}(50 - 16.24)^2 = .29 \times 10^6$

$x_1 = 5''$ $M = \frac{145{,}000}{564}(50 + 5)^2 - 72{,}500 \times 5'' = .4175 \times 10^6$

$x_1 = 10''$ $M = \frac{145{,}000}{564}(50 + 10)^2 - 72{,}500 \times 10'' = .20 \times 10^6$

$I = .0491(D - d)(D + d)(D^2 + d^2) =$
$.0491\ (121.5 - 120.25)\ (121.5 + 120.25)\ (121.5^2 + 120.25^2) =$
$.0491 \times 1.25 \times 241.75 \times 29220 = 434{,}000''^4$

| LOCATION | $M_x \times 10^6$ | $I/C \times 10^6$ | $S_{x_1}$ Lbs. per Sq. In. |
|---|---|---|---|
| At Center | 1.49 | .0072 | 207 |
| At Support | .64 | .0072 | 89 |
| At X = 5″ | .52 | .0072 | 72 |
| At X = 10″ | .41 | .0072 | 57 |
| At X = 16.24″ | .29 | .0072 | 40 |
| At X = 20″ | .232 | .0072 | 32 |
| At $X_1$ = 5″ | .4175 | .0072 | 58 |
| At $X_1$ = 10″ | .20 | .0072 | 28 |

The Stress $S_{x_1}$ in this example is negligent but it is calculated here as part of the example. In some severe cases it may be a more important stress.

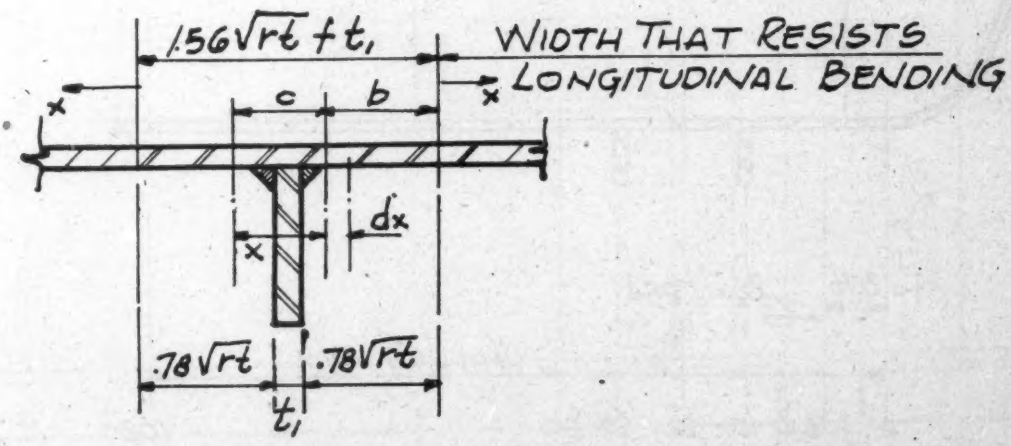



FIGURE 8

### Longitudinal Bending at Rings

$$Mx = \frac{p_1}{4B^3}(e^{-Bb}\ \text{Sin}\ B_b + e^{-Be}\ \text{Sin}\ B_c) = \frac{p_1}{4B^3}[2(B_b) + z(B_c)]$$

$$p_1 = \frac{W}{r_1 \times \alpha \times 2t_1 \times n}$$

$\alpha$ angle of contract in radians
n = No. of rings

$$p_1 = \frac{145{,}000}{60.4375 \times 6.2832 \times 1.25 \times 2} = 157 \qquad \frac{p_1}{4B^3} = \frac{157}{.175} = 897$$

Using 10" as the effective width resisting long. bending we set up the stress

$$\frac{p_1}{4B^3} = 897 \qquad Sx_2 = -\frac{6Mx}{t^2}$$

See Figures 3 &.8

| b | c | Bb | z(Bb) | Bc | z(Bc) | Mx | Sx2 |
|---|---|---|---|---|---|---|---|
| 5 | 5 | 1.046 | .303 | 1.046 | .303 | 545 | 8,400 |
| 6 | 4 | 1.256 | .268 | .835 | .3218 | 530 | 8,150 |
| 7 | 3 | 1.46 | .229 | .629 | .3129 | 485 | 7,460 |
| 8 | 2 | 1.672 | .185 | .419 | .2664 | 406 | 6,260 |
| 9 | 1 | 1.882 | .144 | .2092 | .167 | 279 | 4,300 |
| 10 | 0 | 2.092 | .106 | .... | .... | 95 | 1,465 |

The above stress formulae from Timoshenko's theory of plates and shells.

| LONG STRESS | X =0 | X =3.76 | X =10 | X =15 | X =20 | X =25 | X =30 | X =108 |
|---|---|---|---|---|---|---|---|---|
| Sx | 5,300 | 11,500 | 5,300 | 5,300 | 5,300 | 5,300 | 5,300 | 5,300 |
| Sx1 | 32 | 40 | 57 | 72 | 89 | 58 | 28 | 207 |
| Sx2 | —308 | —247 | 1,465 | 8,400 | 1,465 | 8,400 | 1,465 | ..... |
| Σ | 5,024 | 11,293 | 6,822 | 13,772 | 6,854 | 13,758 | 6,793 | 5,507 |

Allow = 13,750#/□"

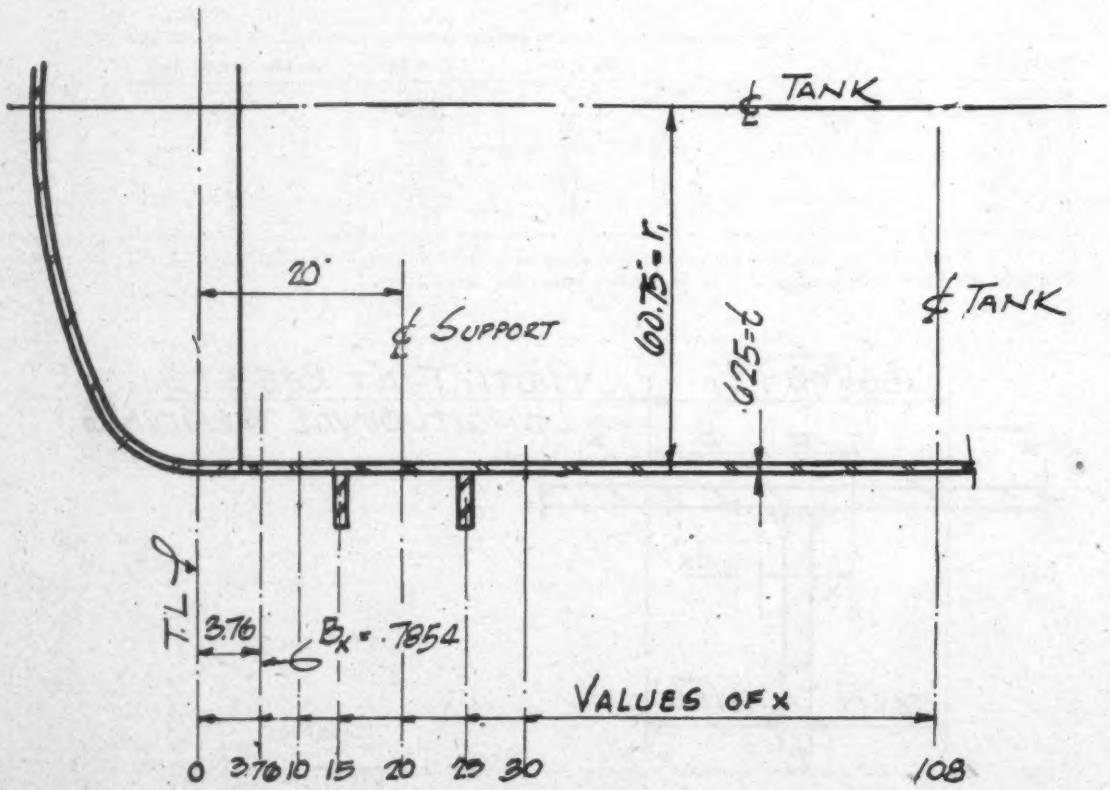



FIGURE 9

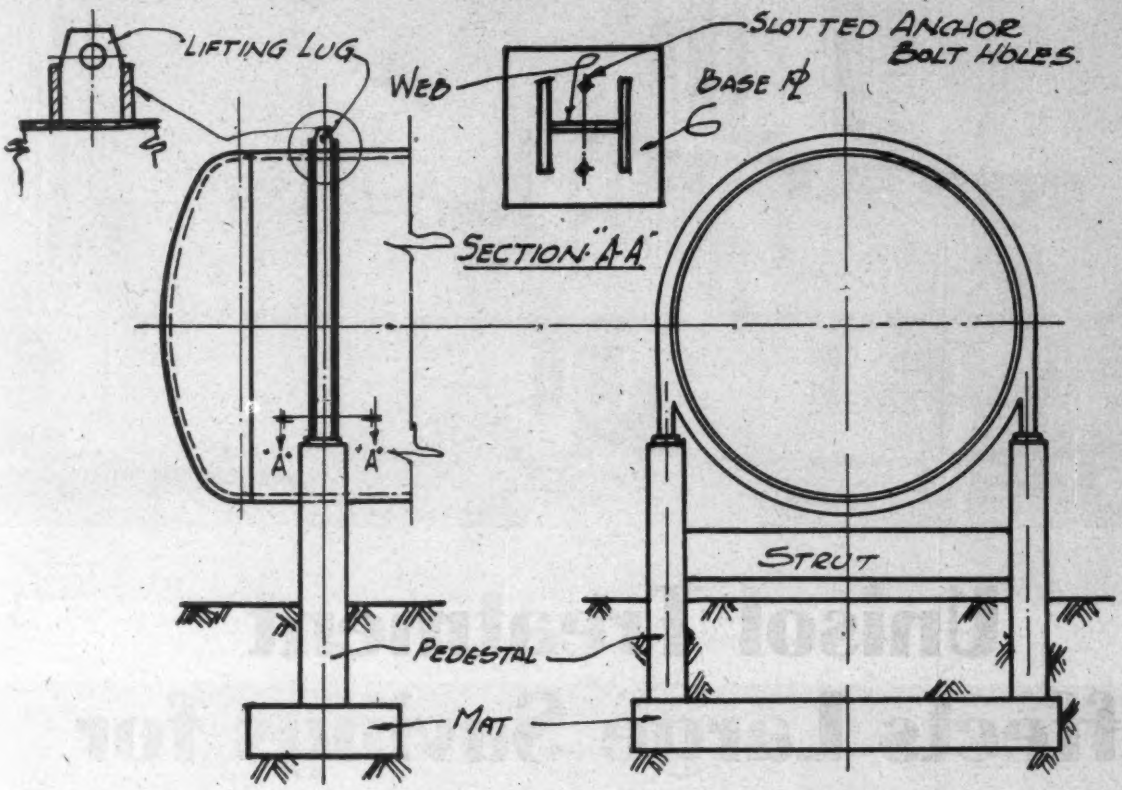
**For Long Stress Beyond Ring**

$Mx = -Mx_{(c=o)}\, e^{-Bx}\,(\text{Sin } Bx - \text{Cos } Bx)$

$e^{-Bx}(\text{Sin } Bx - \text{Cos } Bx) = -e^{-Bx}(\text{Cos } Bx - \text{Sin } Bx) = -\Psi\,(Bx)$

$\Psi(Bx)$ from Timoshenko's theory of plates and shells.

| X | Bx | ΨBx | Mx | Sx2 |
|---|---|---|---|---|
| 0 | 0 | —1.000 | +95 | 1.465 |
| 6.24 | 1.3 | + .1616 | —16 | —247 |
| 10 | 2.092 | + .202 | —20 | —308 |



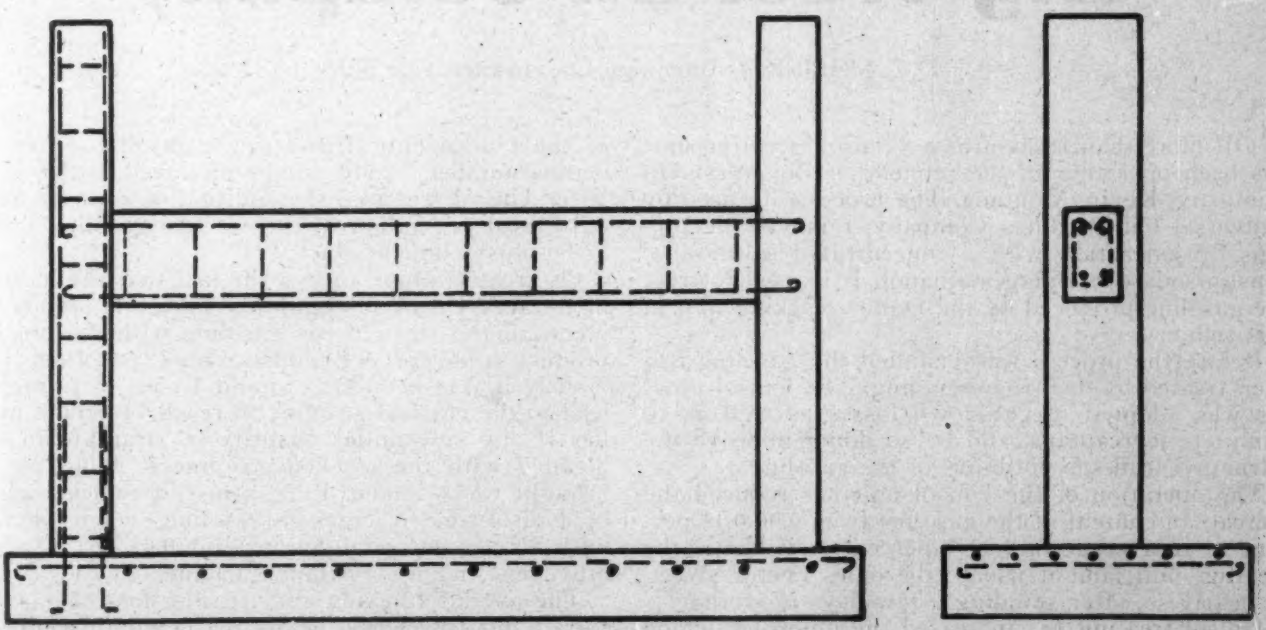
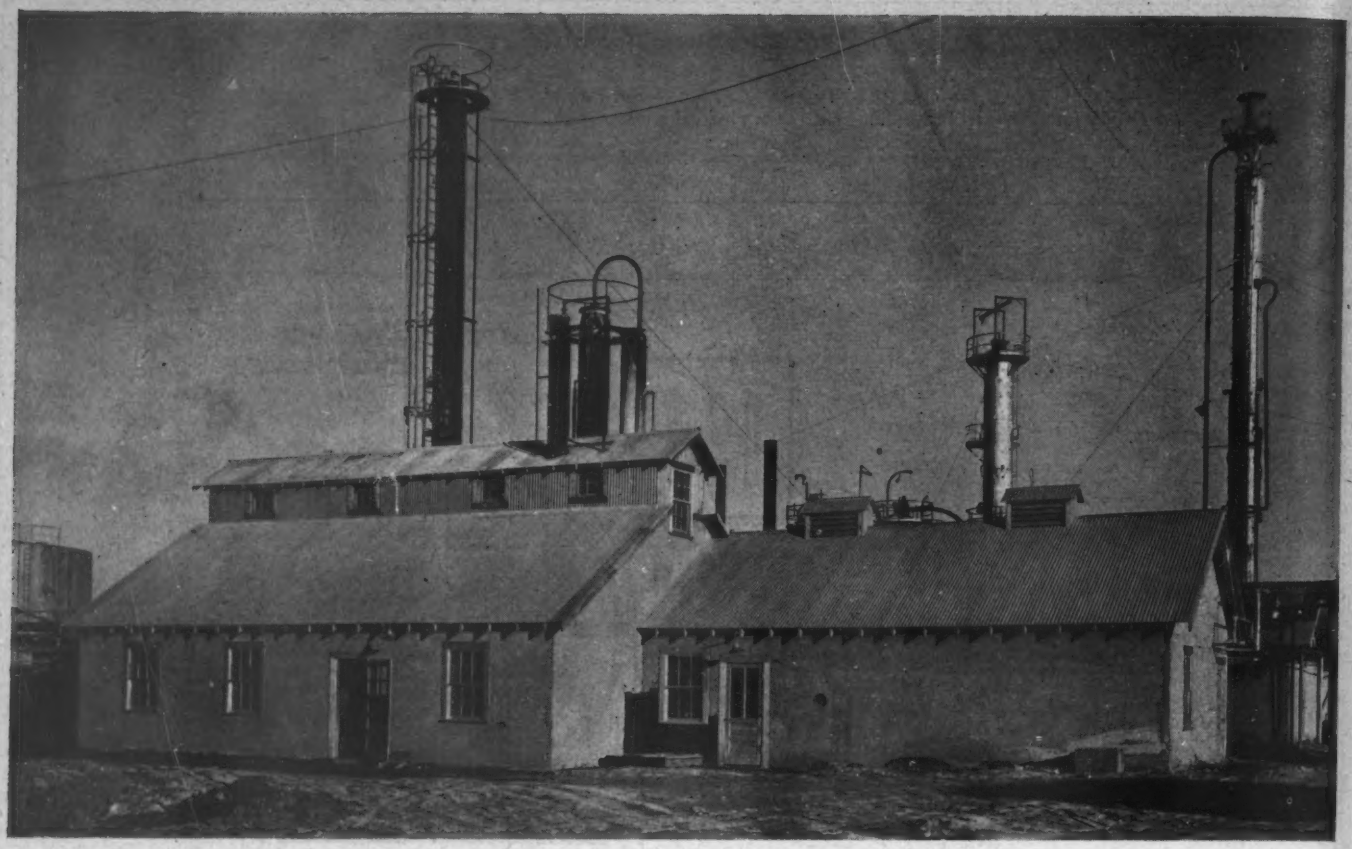



**FIGURE 10**
**Details of Ring Girder and Foundations for Horizontal Tank**



# Unisol Treatment Effects Large Savings for Big West Oil Company

F. C. MORIARTY, Universal Oil Products Company

FOR more than 18 months a "Unisol" treating unit has been operating in the refinery of Big West Oil Company, Kevin, Montana. The process, licensed by Universal Oil Products Company, removes mercaptans by extraction with a concentrated solution of caustic soda containing methanol. It is used to treat the gasoline produced by the Dubbs cracking unit in this refinery.

Before the process was installed the gasoline had been treated by doctor sweetening. The Unisol process was adopted to cut down losses as well as to eliminate mercaptans, and by so doing improve the tetraethyl lead susceptibility of the gasoline.

The operation of the Unisol unit has reduced the mercaptan content of the gasoline from 0.06-0.11 percent to an average of 0.0007 percent as it leaves the treating unit, and it usually becomes doctor sweet, or nearly so, after standing a few days in storage.

Unisol treating has increased the unleaded octane number by one half point. The reduction in mercaptan content is accompanied by a corresponding reduction in total sulfur and a substantial increase in tetraethyl lead susceptibility. Prior to the operation of the Unisol unit, Ethyl grade gasoline (then 80-octane number) could not be produced in the plant. After Unisol treating, the addition of 3 cc. of tetraethyl lead per gallon to the cracked gasoline makes an 80-plus-octane product.

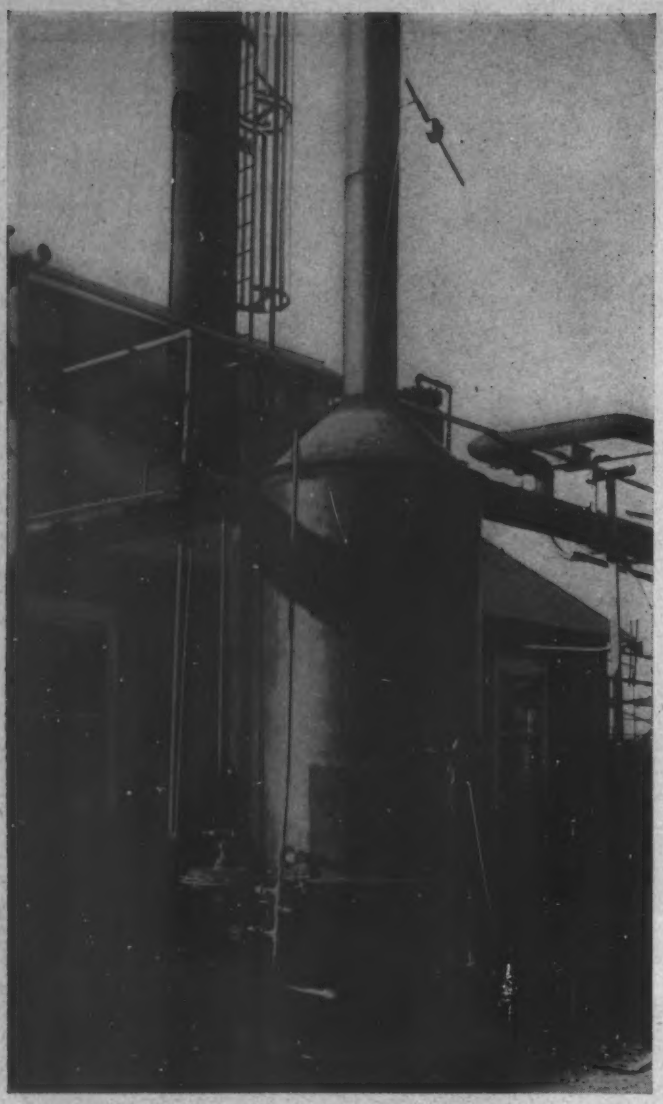
Of greater importance is the fact that the increase in tetraethyl lead susceptibility makes it possible to blend all the straight-run gasoline with the cracked product and produce house brand gasoline. Previously it was necessary to add 1.1 cc. of tetraethyl lead to the cracked gasoline to reach 74-octane number If any substantial quantity of straight-run was blended with the cracked gasoline it could not be brought to 74-octane. By contrast, a typical sample of Unisol-treated cracked gasoline, when blended with 10 percent straight-run and 0.65 cc. of tetraethyl lead, made 75-octane gasoline.

The overall cracking and treating loss of gasoline for a 9 months' period before the new unit went into operation had been 9 percent. The loss over 9 months following the installation was 5.9 percent.

Some of this reduction in loss may have resulted from minor changes in the cracking unit but it is be-

Methanol column receiver and mercaptan separator.

Circulating pump and rotameters.



Steam superheater.

lieved that at least 50 percent of the reduction can be credited to the change in treating.

Analysis of the mercaptans separated from the gasoline shows only a trace of dissolved hydrocarbons. This proves that the loss in treating is insignificant, inasmuch as any gasoline loss would appear in the mercaptan oil.

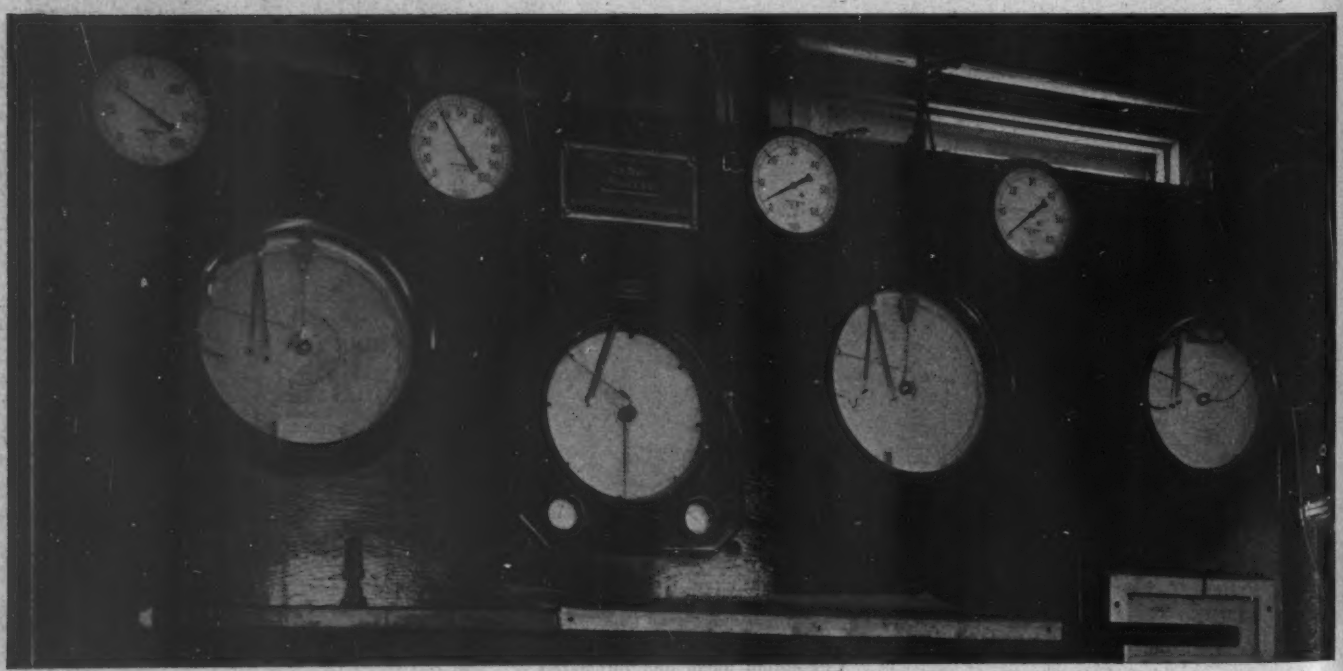
The unit processes approximately 550 barrels of gasoline a day. It is to be expected that losses of reagent in a plant of that capacity would be greater proportionately than in a larger unit, as the smaller unit has the same number of packing glands, sample valves, etc., as the larger one. Nevertheless, the unit consumes less than two gallons per day of methanol, and the total cost of reagents is well below a half cent per barrel treated. Labor costs, too, are low, as only part of the time of one operator per shift is necessary. There have been no process difficulties. However, corrosion in the bottom of the caustic recovery section, which is made of carbon steel, is so severe that it was necessary to replace a 24-inch x 10-foot section after 8 months' service, and it has been necessary to repair it several times in addition. This section is flanged to make replacement easy, and thus has not been a serious handicap to operation of the unit, which to date has made a number of runs well over 100 days in duration. Nickel-clad steel will eliminate the corrosion problem as soon as it is available.

Although the unit is located in northern Montana, where extremely low temperatures prevail in winter, no difficulties have been encountered in operating the process, even under subzero weather conditions.

The inhibitor susceptibility of the Unisol-treated product is excellent. The addition of 0.007 percent of U.O.P. inhibitor No. 4 to the finished gasoline increases the induction period by approximately 250 minutes, and the copper-dish gum (Atlantic method) of the inhibited gasoline has been consistently below 10 mg.

The saving of tetraethyl lead in gasoline, together with the appreciated value of the product and decrease in gasoline loss, has been approximately $30,000 a year, thus indicating a remarkably short retirement period for the initial investment.

Control board.



# Gases at Three Field Pressures Processed by Three Stages Of Compression

HIGH recovery of the light hydrocarbons in exceptional demand for aviation fuel and synthetic rubber ingredients is being accomplished in one West Coast natural-gasoline plant by maintaining its processes in harmony with the conditions under which gas is produced in the surrounding oil field. These wells are produced in two stages of separation, accordingly two gathering systems, one for each stage of separation, have been provided for these streams. In addition all field storage, flow tanks and lease batteries, have been provided with a vapor-recovery system, which feeds into a third set of gathering lines. This system operates at slightly below atmosphere.

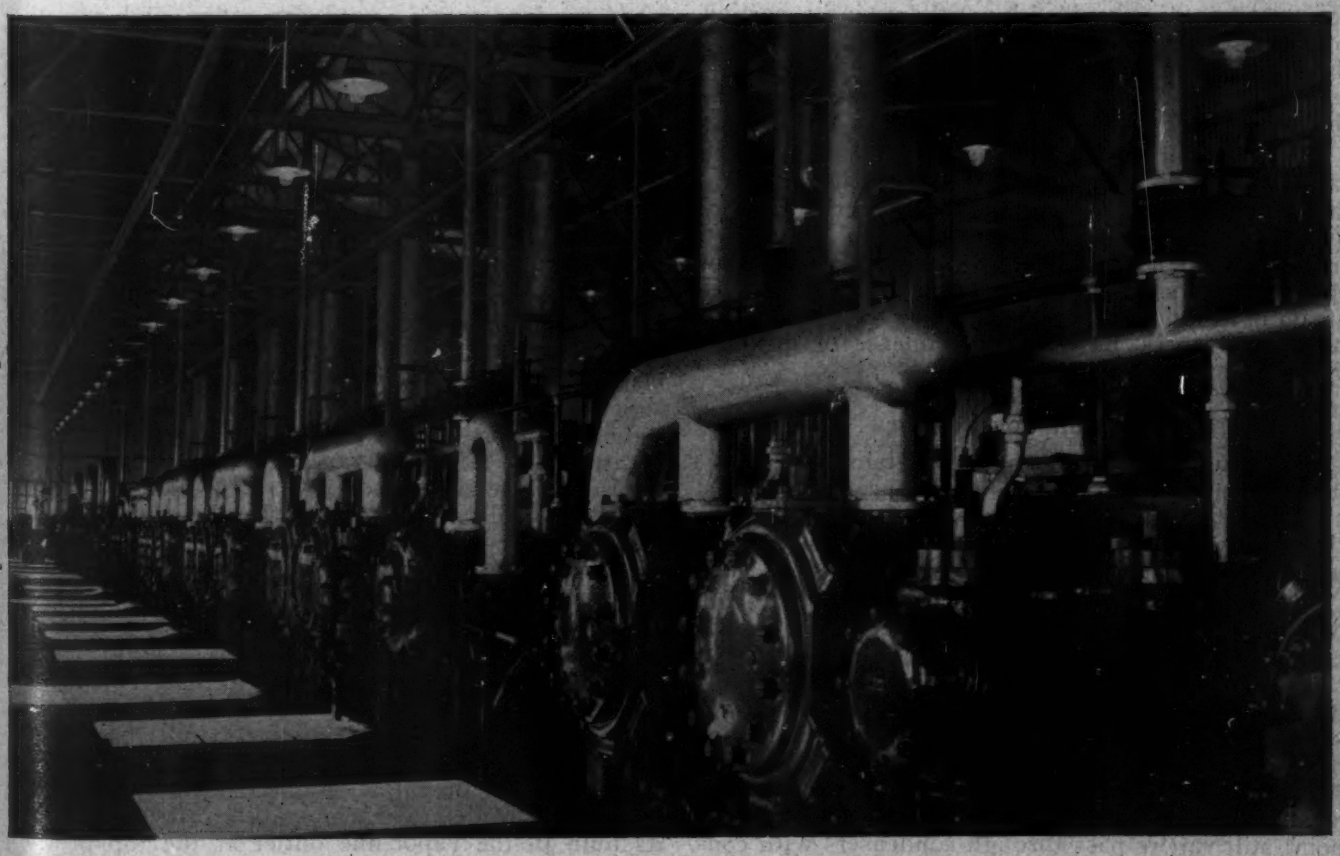
Residue gas is sold to a utility company at 500 pounds pressure, consequently the wet gas from the three systems is raised to 500 pounds in three stages of compression before it is introduced into the absorbers.

The first compression stage, employing 19-inch cylinders, includes all vapors vented through controls in the field and from field tank batteries, also all vapors from the raw-gasoline surge tank, the stable-gasoline storage and all vessels required in processing at 150 pounds, gauge. These vapors pass from the discharge of the low-pressure cylinder into the lines leading from the low-pressure gathering system and flow through atmospheric coolers to the accumulator.

From this accumulator gas is piped to the second stage of compression, using 11½-inch cylinders, which boosts pressure to 155 pounds, gauge, from which it passes through the succeeding set of atmospheric coolers.

A pipe connection at this accumulator admits vapors from the cold rich-oil vent tank so that all vapors at this point are collected for final compression in 6⅜-inch cylinders to 500 pounds, gauge. Gas from final compression passes through another set of coolers to collect condensate.

The difference of 5 pounds between first-stage compression and the plant scrubber on the secondary field separation system permits controls on the inlet scrubber to empty liquids directly into the 50-pound



Compressors equipped with various sizes of cylinders to handle gas through three stages of compression.

accumulators. Condensate from the high-pressure scrubber also is vented directly into the 50-pound accumulator.

In the compression system the 500-pound stage delivers its liquid recovery into the 150-pound accumulator so that vaporized fractions can be vented to the gas stream and partially fractionated by the drop in pressure.

Down the scale of pressures the 150-pound accumulator vents liquids to the 50-pound accumulator for further partial fractionation and compression of released vapors. At the lowest pressure point, the field tank battery vapor scrubber, liquids occurring in the vessel are pumped into the 50-pound accumulator for blending with liquids produced elsewhere by compression.

### Absorption System

The combined stream of field gases and plant vapors enters the absorbers at 500 pounds, gauge, for contact with absorption oil, which is pumped through atmospheric coolers. It is kept in condition in a continuous conditionng unit.

Rich oil is evacuated by motor valve on each absorber and actuated by liquid-level control. It is pumped to the vent tank where pressure is reduced to 150 pounds, gauge, so undesirable fractions can be released before the rich oil passes into the heat-exchanger section of the distillation system. In the heat exchanger the oil is heated to around 220° F. and reduced to 55 pounds, at which it continues through the remaining sections of the heat exchanger and into the distillation columns.

Since the distillation columns serve as both separation and fractionation towers, bubble plates are installed both above and below the rich-oil inlet. Upon entry the oil carries the temperature it has picked up in the heat exchanger, consequently additional heat for processing is provided by withdrawing a portion of the partly stripped oil from the columns and introducing it into a gas-fired tubular heater, from which it is returned to the towers near the point of withdrawal.

This method of heating leaves no necessity for large steam pre-heaters and the withdrawal of partly stripped oil relieves the tubular heaters of large quantities of gasoline vapors, which would be released in the tubes if rich oil were delivered directly from the exchangers. A sufficient quantity of low-pressure steam is introduced into the columns for building up partial pressures, necessary for release of gasoline vapors from the oil.

### Fractionation System

Top column temperatures are maintained by pumping all condensate from the low-pressure accumulator as reflux. Only the liquid that will clarify readily in the still is used for reflux. Unstable material is collected in a slop tank for conditioning in a small still.

The amount of condensate is never adequate for proper top temperature control, so a secondary source is maintained by pumping from the raw gasoline surge in quantities sufficient for control. The discharge of this pump is operated by an automatic temperature instrument with a bulb on the vapor outlet of the stills which by passes excess gasoline reflux back to the suction to make sure that columns never have more liquid return than is required. End-point still vapors pass through condensers with condensate and uncondensed vapors, entering the raw-gasoline surge tank from which vapors are released into the vacuum system for reprocessing.

Absorption oil make-up is provided by pumping from storage into the circulating system between the lean-oil cooling sections and the lean-oil booster pump. Fresh oil also may be introduced by a charge pump into the circuit between the cold-oil vent tank and the heat exchangers. The oil system can be vented by opening a valve on the connection between the lean-oil coolers and the booster pump.

Since all fractions except methane and ethane are required in processing and butanes are especially sought, close control is maintained over discharge into the fuel lines. All cooling and condensing equipment is maintained at high efficiency.

From the surge tank raw gasoline goes into the first column for immediate removal of ethane. From a conventional heat exchanger it enters the column, which is operated to maintain a constant working level of condensate in the reflux accumulator. This level control causes two operating valves on the overhead vapors to open the flow through the condensers for normal makeup and to actuate the by-pass valve around the condensers to prevent condensation of excess reflux. All vapors from the reflux accumulator pass through a pilot-operated back-pressure valve which vents vapors into the fuel system or into the commercial lines.

### Control for Specifications

Variation in the composition of the raw gasoline calls for changes in reflux requirement, which is determined by wethering tests and fractional analysis. The objective in this column is removal of all ethane with sacrifice of propane.

The depropanizing column is operated to recover relatively pure propane as an overhead product, which after condensation is used for reflux and run to storage.

This column is so operated that propane is fractionated in the section above the feed nozzle. Especially close control is maintained to prevent escape of iso-butane overhead.

The next column can be operated so as to recover bottom products of required specifications from butane-free to commercial vapor-pressure gasolines. If a specified vapor-pressure material is required, operating conditions are adjusted to release both butanes overhead. Temperature, pressure and reflux controllers permit recovery of a butane-free base product, which does not cut pentanes overhead.

Separation of the butanes requires especially designed columns, operated within close pressure, temperature and reflux tolerances. The overhead from the iso-butane column holds to a high state of purity; once the equilibrium in operation has been established for separation of butanes. The column is equipped with close-range temperature controllers on the reboiler and the reflux supply to prevent fluctuations within the tower.

Overhead condensation is provided by atmospheric coolers, from which it is returned to the accumulator for transfer to storage or back to the top plate of the column as reflux. Two pumps are required for handling liquefied iso-butane, one actuated by the liquid-level controller on the accumulator, while the reflux pump is controlled by a temperature instrument with its bulb in the vapor-line outlet at the top of the column.

# Application of Unit Operations To Fractionation and Other Vaporization Processes

## PART 5

### Calculation of Evaporation Losses from Large Atmospheric Storage Tanks

R. L. HUNTINGTON
School of Chemical Engineering
University of Oklahoma

ALTHOUGH vapor-saving devices and installations have been perfected to a high degree, there is still a large number of atmospheric storage tanks which are not protected in any way from the weather and the consequent loss of lighter gasoline fractions, resulting from the inhalation of air at night, and the exhalation of air and fresh gasoline vapor by day. The use of a light colored paint, such as exterior white or aluminum on the surface of the tank has been found helpful in the reduction of evaporation.[4] The spraying of tank roofs with water is an effective method of preventing excessive losses, since breathing is minimized by the lowering of vapor temperature during the daylight hours.

It is the purpose of this paper to show how approximate vapor losses can be calculated with a meager amount of temperature data. Such calculations are practically required in view of the difficulty encountered in securing accurate measurements of losses by taking tank gages. Furthermore, most large tanks will not withstand pressures sufficient to force the escaping air-vapor mixture through an orifice, or positive meter.

Vapor and liquid temperatures are needed in order to estimate the actual breathing which takes place. It is desirable to have recorded temperatures of vapor and liquid over a 24-hour period. If the tank has a 55,000- or 80,000-barrel capacity, several temperature readings of each phase should be taken so as to make sure that average conditions may be obtained. In spite of convection currents, temperatures are apt to be the warmest near the side of the tank exposed to the sun, and conversely, the coldest temperatures after sunset will be found near the walls and roof.

Vapor temperatures in a tank will often go as high as 30 or 40° F. above the air temperature on clear, sunny days when there is little wind. At night, however, the air and vapor temperatures will tend to approach each other, so that the vapor may be only 2 to 10° F. above the air temperature, early in the morning just before sunrise. The high vapor temperature at noon, or shortly thereafter, is the result of the conversion of radiant energy, into heat energy on the surface of the tank, which may reach a temperature of 140 to 150° F., some 20 to 30° F. higher than the vapor inside the tank. The loss of heat, by radiation and convection, from the tank to the cooler surroundings, cannot begin to keep up with the rapid absorption of radiant energy from the sun when it is high in the sky, until the vapor in the tank is considerably warmer than the outside atmosphere.

The liquid in the tank picks up some radiant energy from the sun through the walls of the tank; however, the far greater mass and heat capacity of the liquid causes this phase to lag behind in temperature change. Consequently, the liquid in a tank may vary only 2 or 3° F. between day and night. Vaporization in the daytime tends to cool the liquid, and condensation of part of the gasoline vapor has a heating effect at night, both of these factors tending to keep the liquid constant in temperature over the 24 hours.

#### A Simplified Method of Calculation

The following data are typical of summer conditions in an 80,000-barrel tank, half full of Mid-Continent crude oil. (Figure 1).

| | Temperatures | |
|---|---|---|
| | Minimum | Maximum |
| Atmosphere | 65 °F. | 90 °F. |
| Vapor Space | 70 | 110 |
| Liquid Space | 85 | 89 |
| Vapor Pressure, Lbs./Sq. In., Abs. | 2.7 | 3.2 |

It is assumed that equilibrium exists between the vapor space and the crude oil based on the temperature of the latter at all times, and that the average temperatures are arithmetical between the extremes of day and night.

If the absolute pressure in the tank is 14.7 pounds per square inch, the respective partial pressures of air and crude oil vapor will be 11.5 pounds and 3.2

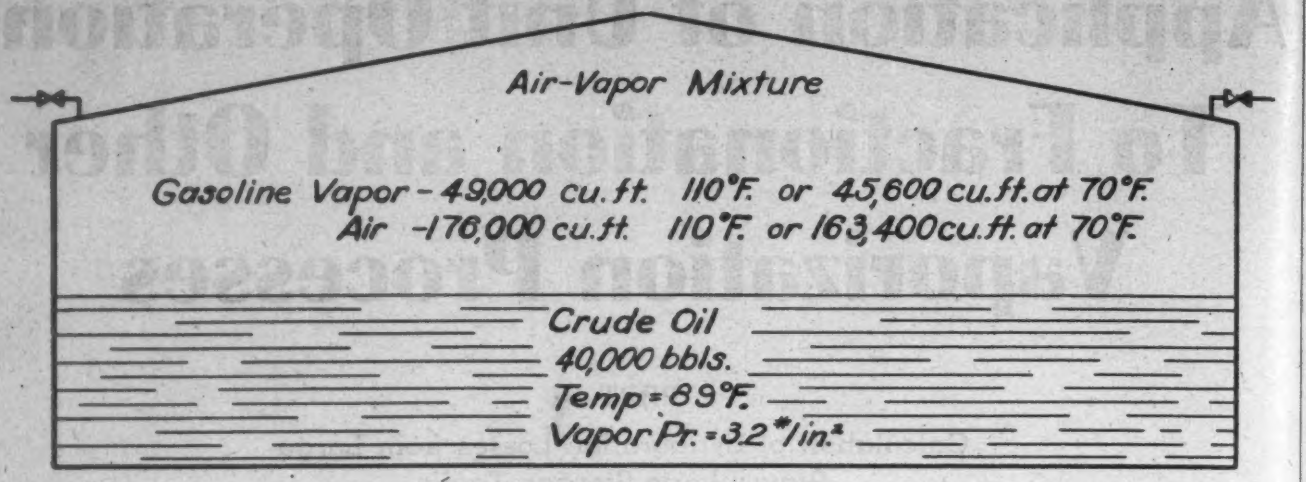

Air-Vapor Mixture
Gasoline Vapor - 49,000 cu. ft. 110°F. or 45,600 cu. ft. at 70°F.
Air - 176,000 cu. ft. 110°F. or 163,400 cu. ft. at 70°F.
Crude Oil
40,000 bbls.
Temp = 89°F.
Vapor Pr. = 3.2 #/in.²

**FIGURE 1**

**Conditions existing in an atmospheric crude-oil storage tank in the hottest part of the day.**

pounds per square inch, absolute, respectively, in the hottest part of the day. In the coolest part of the night, the corresponding partial pressures for the air and vapor will be 12.0 and 2.7 pounds per square inch. The volume percentage of vapor is proportional to its partial pressure, therefore the percentage of gasoline vapor in the hottest part of the day will be

$$\frac{3.2}{14.7} \times 100 = 21.80 \text{ percent}$$

(Figure 1) and the coolest part of the night,

$$\frac{2.7}{14.7} \times 100 = 18.35 \text{ percent}$$

(Figure 2).

### Air Inhaled At Night

If no condensation took place at night, the shrinkage of the air-vapor mixture could be estimated by the perfect gas law as follows:

| Cu. Ft. Vapor Space | Temp. Correction | Cu. Ft. at 70°F. |
|---|---|---|
| 225,000 | $\times \frac{530°\text{F. abs.}}{570°\text{F. abs.}}$ | = 209,000 |

225,000 — 209,000 = 16,000 cu. ft. of shrinkage.

This means that 16,000 cubic feet of air at 14.7 pounds per square inch pressure and 70° F. would have to be inhaled to prevent the collapse of the tank.

A further analysis of the data reveals that additional air is inhaled as the result of partial condensation of the gasoline vapor. The gasoline-vapor volume in the hottest part of the day is 225,000 × .218 = 49,000 cubic feet and at night only 225,000 × .1835 = 41,300 cubic feet. If the 49,000 cubic feet of 110° F. vapor is cooled at 70° F., its volume would be

$$49{,}000 \times \frac{530}{570} = 45{,}600 \text{ cubic feet}$$

From the above figures, it is seen that 45,600 — 41,300 = 4300 cubic feet of gasoline vapor (at 14.7 pounds and 70° F.) have been condensed. Neglecting changes in the liquid volume in the tank, due to temperature changes, and the condensation of part of the gasoline vapor, it is easily seen that 16,000 + 4300 = 20,300 cubic feet at 70° F. air have been inhaled at night.

### Exhalation of Air and Gasoline Vapor

During the warming-up period for the tank, between dawn and the middle of the afternoon, air and

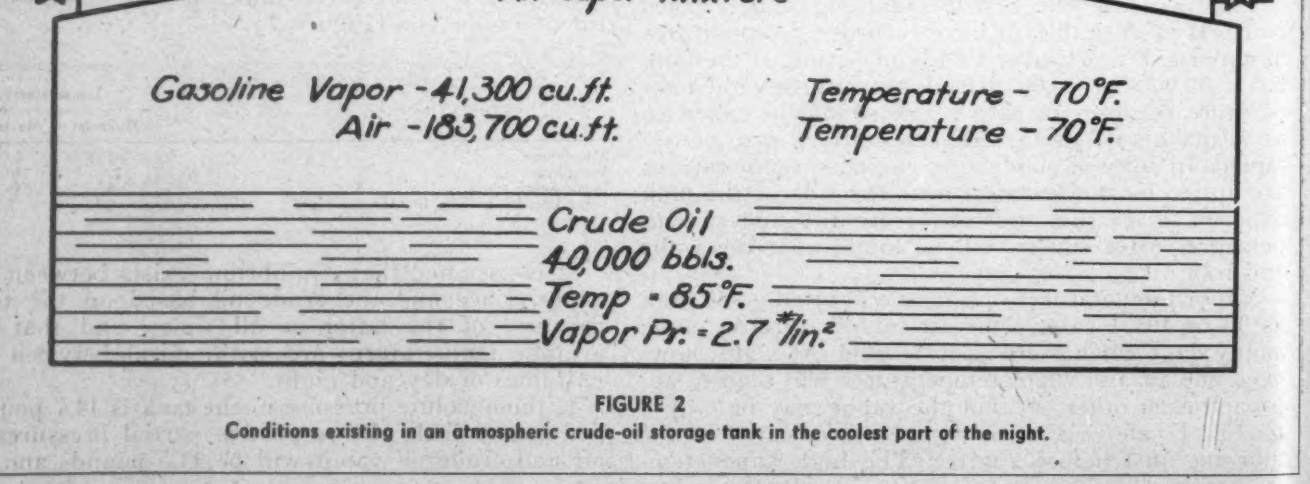



**FIGURE 2**

**Conditions existing in an atmospheric crude-oil storage tank in the coolest part of the night.**

gasoline vapor are exhaled. This "breathing out" is caused by the rise in vapor temperature, and also by the evolution of vapor, resulting from the rising temperature of the crude oil.

The first gas which escapes from the tank in the morning will consist of 18.35 percent gasoline vapor and 81.65 percent air, and by the hottest part of the day the gas will have 21.80 percent gasoline vapor. If the change in the composition of the gas is linear, the average composition of the gas will be 20.075 percent gasoline vapor at an average temperature of 90° F. Since all of the air which was inhaled the night before will be exhaled, there will be 79.925 volumes of air for every 20.075 volumes of gasoline vapor escape from the tank. There will be

$$20{,}300 \times \frac{550}{530} = 21{,}000 \text{ cubic feet}$$

of 90° air exhaled and along with the air,

$$21{,}000 \times \frac{20.075}{79.925} = 5280 \text{ cubic feet}$$

of 90° F. gasoline vapor. If the gasoline vapor is comparable to that of normal pentane, the liquid volume equivalent to 5280 cubic feet of 90° F. vapor will be:

Temp. Correction

$$\frac{5280}{27.7} \times \frac{520}{550} = 180 \text{ gallons}$$

or

$$\frac{180}{42} = 4.28 \text{ barrels}$$

where 27.7 = standard cubic feet of vapor evolved by evaporation of 1 gallon of normal pentane.

This set of calculations has been based on the assumption that the vapor pressure of the crude oil will not fall during the 24-hour period. Actually the vapor pressure of the crude oil will fall from day to day, and likewise the evaporation rate will decline, somewhat rapidly at first and more slowly after a storage period has elapsed.[1,2,3]

## Conclusions

More experimental and actual storage data are needed before these evaporation losses can be accurately determined through calculations based on temperature changes. It is entirely possible that the equilibrium temperature may be as near the vapor temperature as it is to that of the liquid, due to a warm surface film.

From the foregoing estimates, it is easy to see that the vapor space above the liquid should be reduced to a minimum in order to prevent excessive breathing losses.

It has been found from experience, however, that breathing losses increase up to liquid outages of approximately 10 percent above which the losses are practically constant. This phenomenon is due to the fact that the air does not mix very readily with the vapor in tanks containing the small amount of liquid since the vapor is usually 2 to 4 times as dense as the atmosphere.

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2. Lewis, W. K., and Coleman, Stewart P., The Oil and Gas Journal, May 5, 1931.
3. Rogers, W. K., The Petroleum Engineer, June and July, 1936.
4. Schmidt, Ludwig, Applied Methods and Equipment for Reducing Exaporation Losses of Petroleum and Gasoline, Bureau of Mines, Bulletin No. 379, 1934.


Solutions to last month's review exercises are as follows:

1. A certain crude oil when saturated with a mixture of hydrocarbon gases at 2600 pounds per square inch and 130° F. had an API gravity of 55. Upon release of pressure down to atmospheric, the crude-oil volume had shrunk to 74 percent of its original volume and the gravity was then 40° API. What was the API gravity of the dissolved gases before their release from solution?

$$\text{Sp. Gr. compared with water} = \frac{141.5}{131.5 + {}^\circ\text{A.P.I.}}$$

Sp. Gr. of 55° A.P.I. original reservoir crude =

$$\frac{141.5}{131.5 + 55} = .759$$

Sp. Gr. of 40° A.P.I. residual crude after release of pressure down to atmos. $= \frac{141.5}{131.5 + 40} = .825$

Wt. of original bbl. of crude oil and dissolved gas = Wt. of fractional part of bbl. of residual crude oil + Wt of fractional part of bbl. of dissolved or liquefied gases.

Let $\times$ = sp. gr. of dissolved gases

$.759\ (8.33)\ (42) = .74(.825)(8.33)(42) + .26(\times)(8.33)(42)$

Solving for $\times$, we get:

$.759 = .74(.825) + .26\times$

$\times = .57$ (sp. gr. of dissolved or liquefied gases)

$$\text{Then } .57 = \frac{141.5}{131.5 + {}^\circ\text{A.P.I.}}$$

A.P.I. = 116.5 (which is about the same liquid density as normal butane)

Note: Most Mid-Continent crude oils shrink about 2.5 percent by volume for each degree °A.P.I. loss in gravity, resulting from atmospheric storage.

2. A natural gas consisting of methane and ethane had a specific gravity versus air of 0.60. What percentage by volume of the gas was methane?

$$\text{Methane has a sp. gr. vs. air} = \frac{16}{29} = .552$$

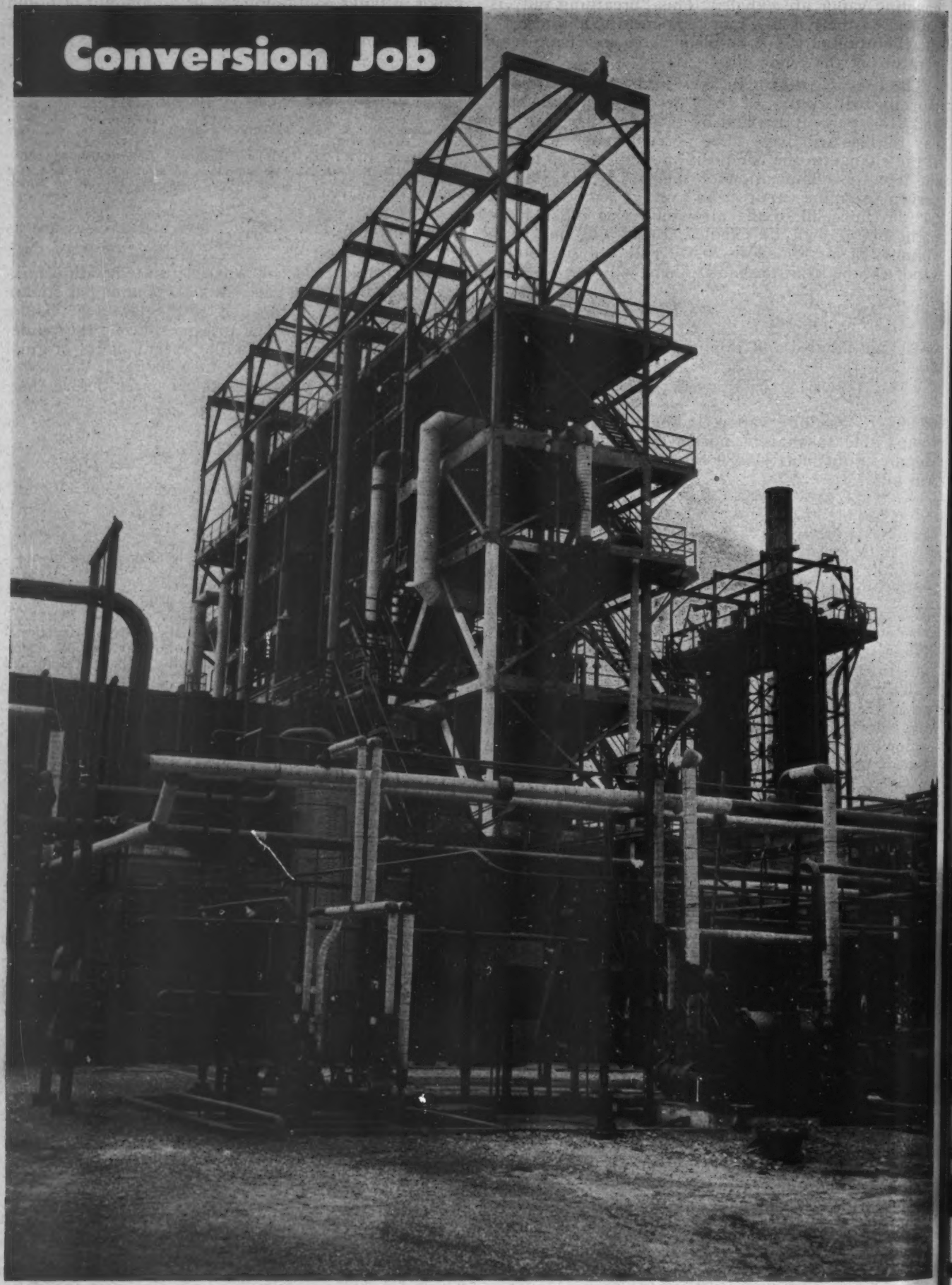
Ethane has a sp. gr. vs. air = 30/29 = 1.035

Let $\times$ = volume fraction of methane in the gas. A weight balance can then be written

$.552\ (\times) + 1.035\ (1 - \times) = .60$

$\times = .747$ (or 74.7 percent by volume of gas is methane).

# Conversion Job



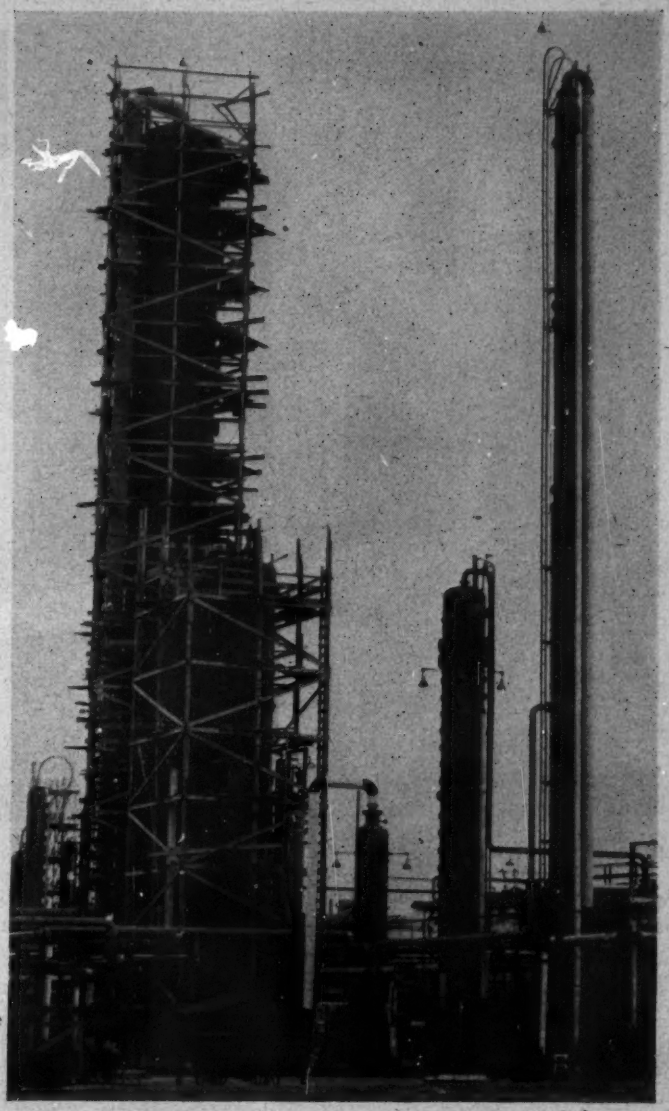
Larger piping and vapor lines to permit operation at reduced pressure were provided to convert the tube-and-tank thermal-cracking units to the high-temperature production of butadiene. Two units, part of the Ingleside plant, were thus put into butadiene processing.

# E Pluribus Unum

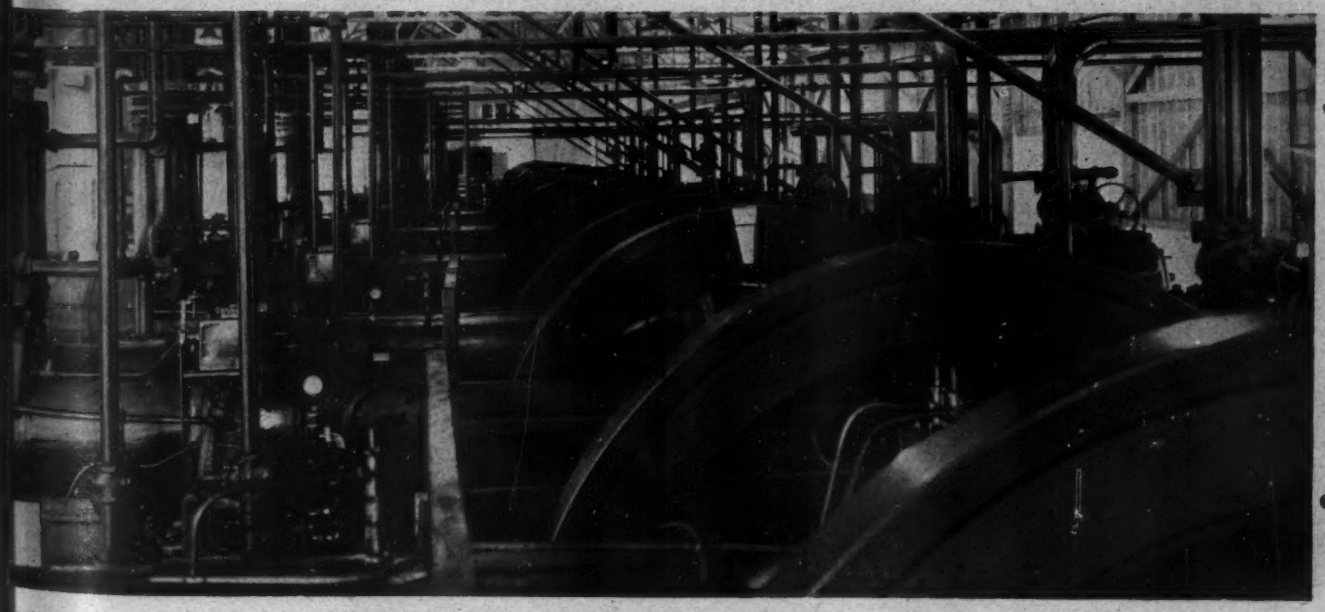
ONE of the successful conversion jobs of the butadiene part of the synthetic rubber program is now functioning at above its rated annual capacity of 7500 tons per year at Ingleside, Texas. Here Humble Oil & Refining Company assembled materials from its own refineries, its natural gasoline plants, its production department and from other companies and put them into a thermal butadiene unit, designated as Plancor 1518 by Defense Plant Corporation.

History of some of the equipment reveals the extent of this conversion job. The unit has 61 pumps, only two of which were purchased on priority ratings; of its 1058-horsepower from steam turbines, only 212 horsepower is from new equipment; compressor horsepower is 4000, still one new unit of 300-horsepower and parts for another unit are the only new equipment in this service; electric-motor horsepower of 1424 was provided with the purchase of only 11 new motors of 330 total horsepower; instruments are 90 percent from other services; the plant required 2300 tons of steel but only 650 tons required priority orders.

The manufacturing unit was provided by converting two Tube and Tank thermal cracking units to butadiene processing. These had been in operation at Ingleside since 1929 and in refining service operated at 125 pounds on the fractionating equipment. The lower pressure for butadiene processing was ac-



Three bubble towers from the Baytown refining plant were welded together to form the main tower, left, of the butadiene extraction unit. Several lengths of 24-inch pipe were used to make the redistillation column, right. All towers in this unit came from other refining services or from large diameter pipe.



Compressors from natural-gasoline plants of the company were assembled for the vapor recovery of the manufacturing unit. The house was provided from a dismantled gas-absorption plant in the Raccoon Bend field.

Additions to the gas-recovery unit of the refining plant were provided to give this unit sufficient gas-recovery capacity. The three towers on the right were in refinery service. The two vertical drums, left, for clay treating, came from an alkylation plant and a dismantled refinery. The four fractionating columns in the center had been idle since 1934 when the Yates (West Texas) gasoline plant was dismantled.

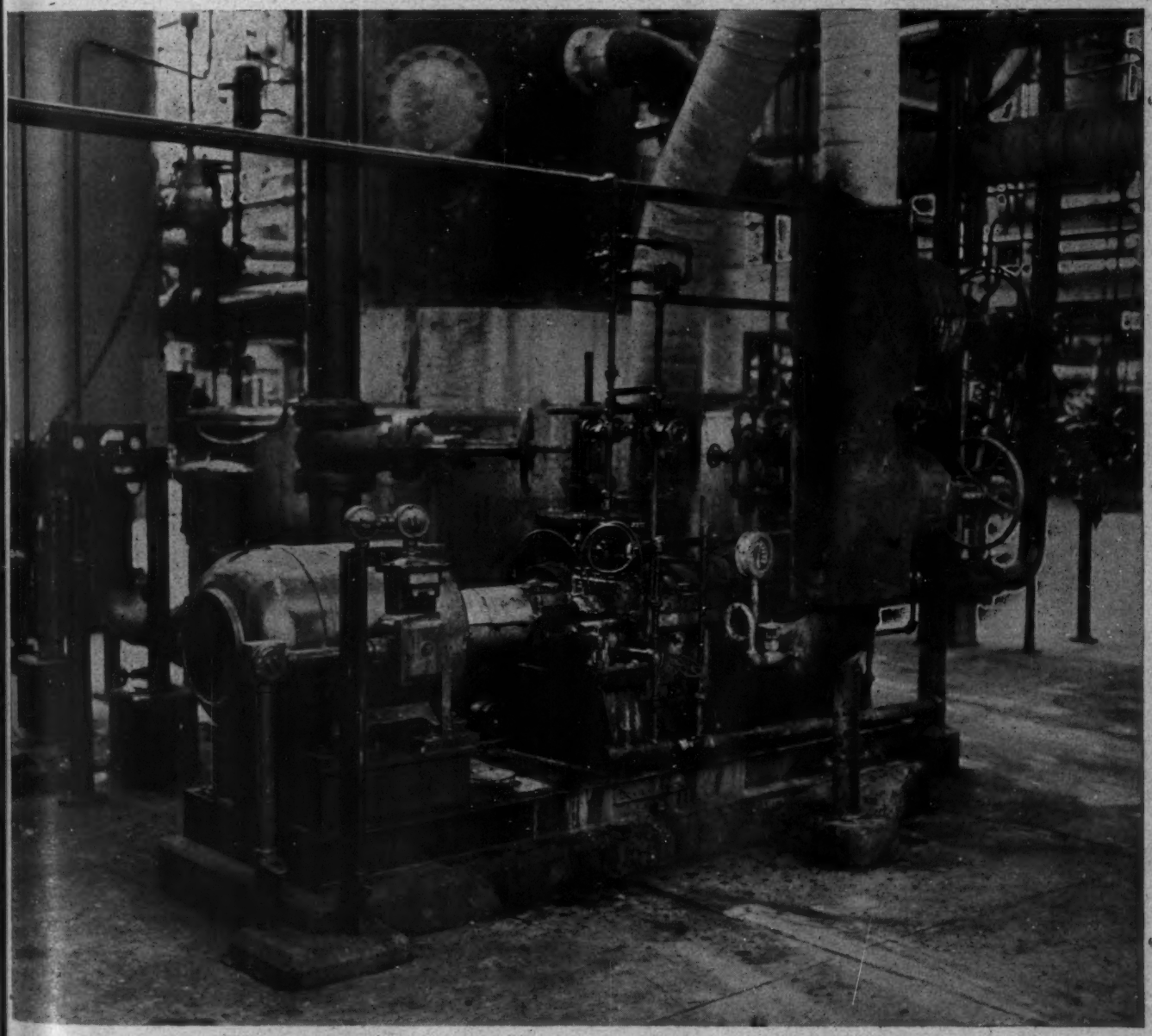
As a charge pump on the reforming heater of the cracking coils this pump had a discharge head of 1800 pounds. By removing some impellers discharge head was reduced to 450 pounds, the charge pressure needed for the butadiene manufacturing unit. It has a dual drive.

complished by providing larger piping and vapor lines, which were found in other refining plants.

The gas-recovery unit has 11 compressors, all taken from natural gasoline plants of the company. Three existing towers at Ingleside were kept in place, while four other columns and two drums were assembled from other plants. Three columns came from a natural gasoline plant, which was dismantled at Yates in 1934. Another formerly was in gas recovery service at the Baytown plant. One of the clay treating drums was reclaimed from an old refinery at McCamey and the other was intended for use in an alkylation unit at Ingleside.

In the extraction unit a tower, 114 feet tall, was provided by welding together three bubble towers, previously put in service in 1926 at Baytown. Its redistillation column, 88 feet high, was made from 24-inch pipe. The desorber tower, 43 feet high, was manufactured in 1929 and came from an abandoned refining plant. Two additional towers came from Baytown surplus. One previously had been used as a sulphur treating tower; the other one was purchased in 1930 to a now abandoned hydrogenation project.

**The control board shows an assembly of instruments from many sources, with only 10 percent provided through priorities.**



**This pump was designed for handling boiler feed water at 225° F. and bought for the alkylation unit. By providing it with extra deep stuffing boxes it met the requirements of handling bottoms from one of the stripping stills at 500° F.**

# Oil Dewaxed and Wax Deoiled In Simultaneous Operation

EMIL E. EBNER, General Superintendent of Refineries, Quaker State Oil Refining Corporation
and
F. T. MERTENS, Process Engineer, Foster Wheeler Corporation

THE Quaker State Oil Refining Corporation recently placed in operation at its Emlenton, Pennsylvania, refinery a new lubricating-oil and wax plant for the production of low-pour-point, high-viscosity-index motor, heavy-duty and aviation oils, and for the manufacture of high-purity, oil-free-crystalline and micro-crystalline waxes.

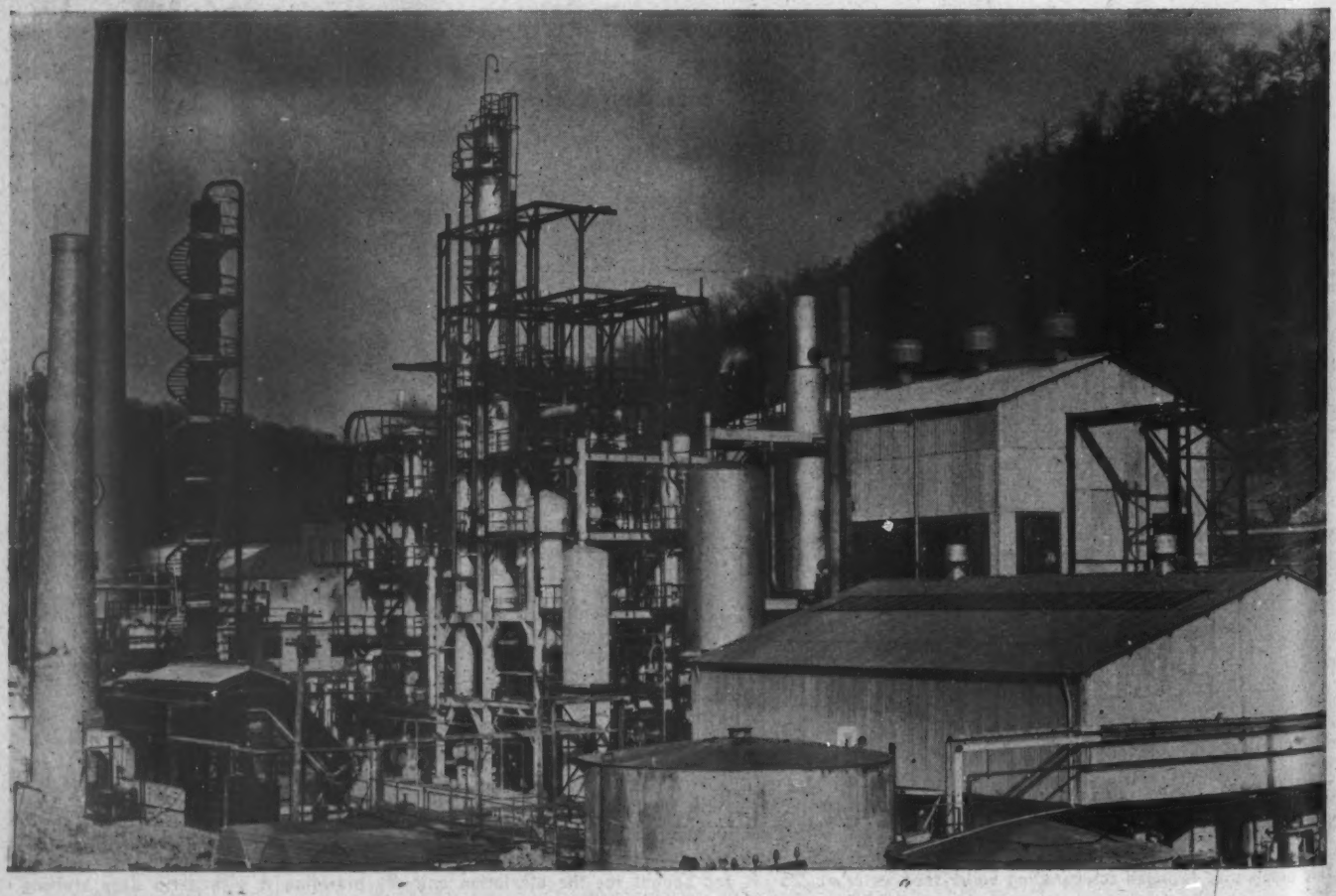
The capacity of the clay percolation plant was also increased by the addition of another clay regenerating furnace to increase the output of low-carbon-residue bright stocks and of light-colored grades of micro-crystalline waxes.

The new plant consists of methyl ethyl ketone-benzol solvent dewaxing and wax recrystallizing units and a furfural solvent extraction unit.

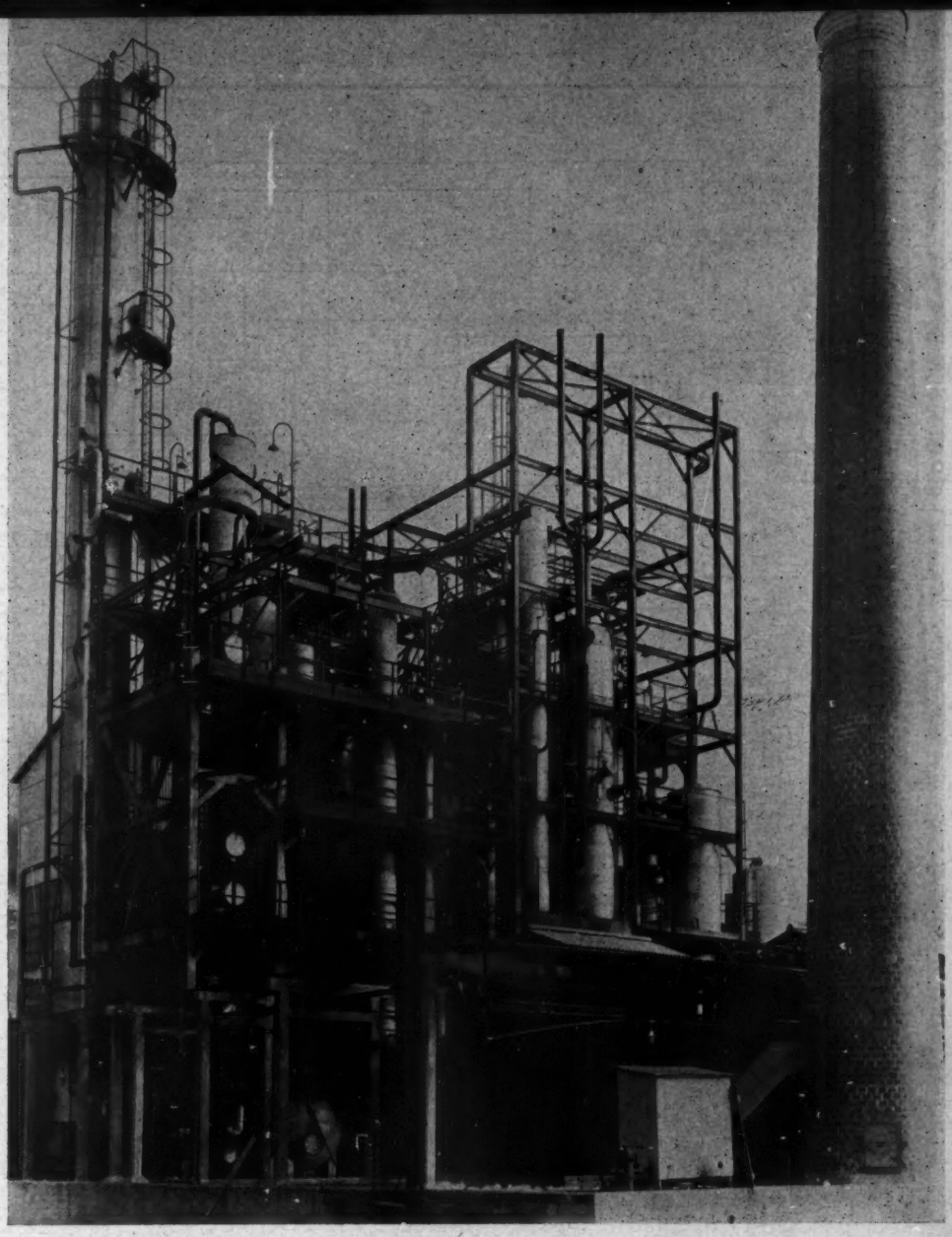
The methyl ethyl ketone-benzol solvent plant is designed to permit simultaneous dewaxing of raw lubricating-oil fractions from Pennsylvania crude oil into finished low-pour-point oils, and recrystallizing of crude waxes into finished deoiled and fractionated waxes in a wide variety of melting points. This simultaneous operational feature is unique and the installation at Emlenton is the first of its kind to be so constructed.

Quaker State Oil Refining Corporation engineers worked out the design of the solvent dewaxing and recrystallizing plant with Texaco Development Corporation, which licenses the processes and Foster Wheeler Corporation was awarded the contract for the detailed design and construction of the unit.

The design and operation of the wax deoiling and recrystallizing sections of the new plant were evolved from several years of laboratory research and development on improved methods for wax deoiling, frac-



General plant view furfural refining and solvent dewaxing units.



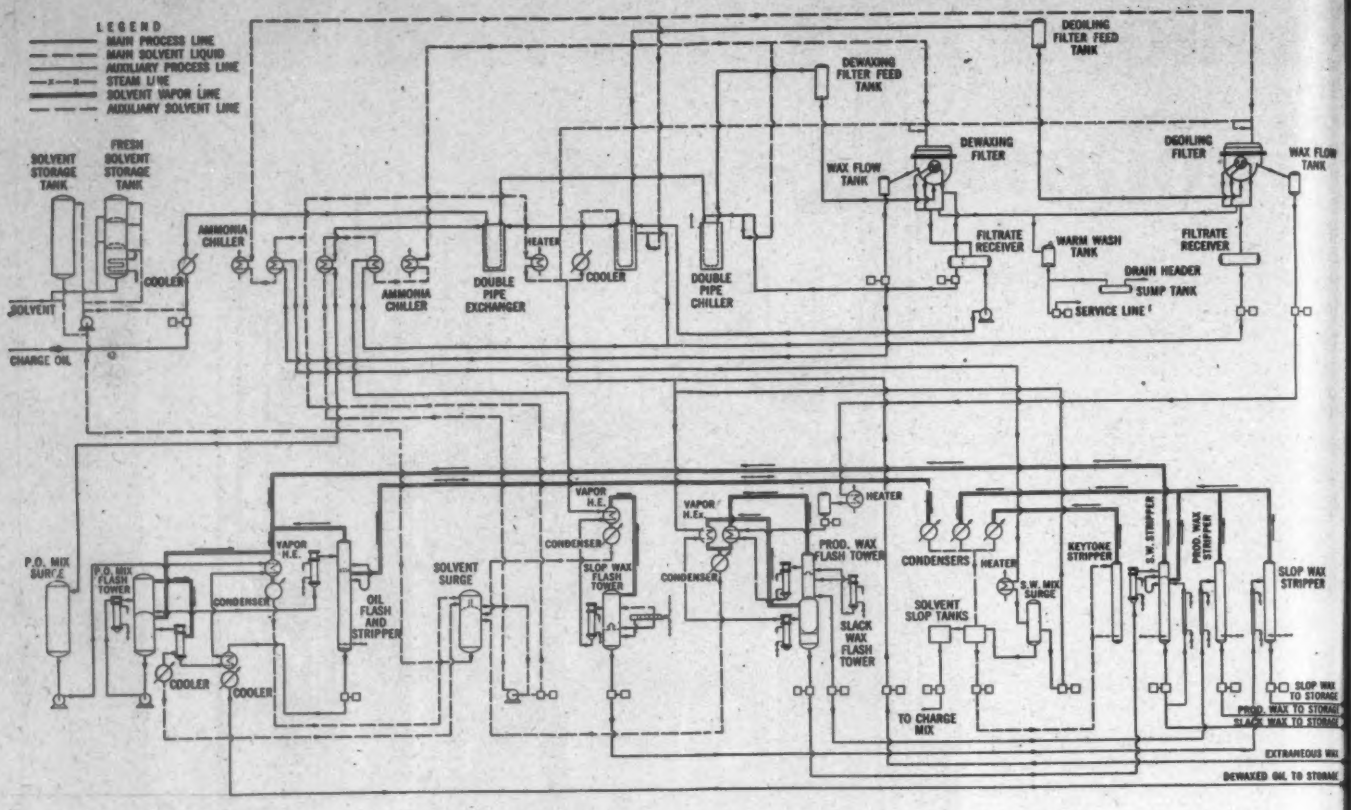
Treating tower and recovery systems for furfural and dewaxing units.

tional recrystallization and purification. The earlier phases of this laboratory work led to the construction in 1936 of a methyl ethyl ketone-benzol dewaxing plant at the McKean refinery of Quaker State Oil Refining Corporation. This was the first commercial application of ketone-benzol solvent dewaxing and deoiling in the Pennsylvania refining area. While this earlier plant was primarily intended for dewaxing and deoiling, it was also used for full-scale recrystallization and purification of waxes, following procedures developed in the laboratory. These full-scale trials in 1936 through 1939 confirmed the laboratory work that the ketone-benzol solvent process could be utilized to produce closely fractionated waxes of very low oil content with much greater efficiency and precision than was possible by the conventional methods of sweating, repressing or multiple-centrifuging.

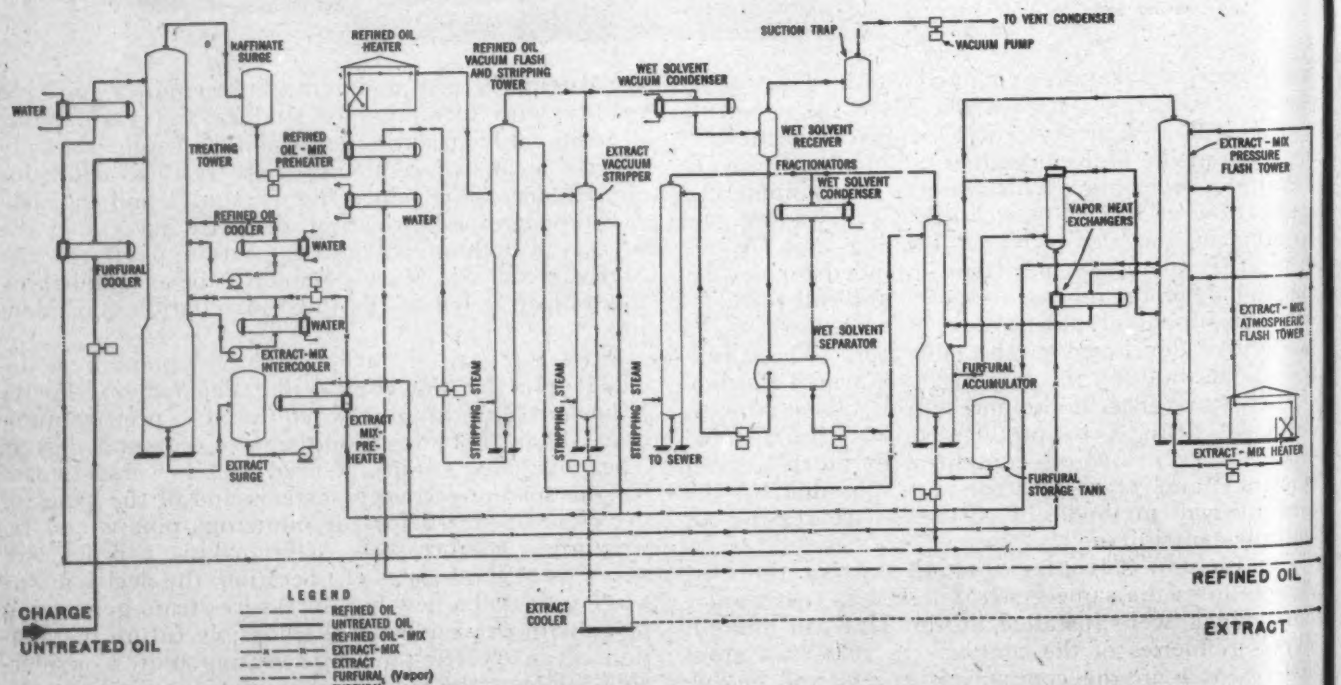
The furfural solvent extraction unit of the new plant follows the same general design as two similar units which were installed at the McKean and St. Mary's refineries of the company in 1938-39. Extensive research in the company's process and engine laboratories had demonstrated that motor and aero oils refined by conventional methods of distillation and clay treatment still retained small concentrations of unstable constituents which, on exposure to elevated temperatures and aeration in engines, oxidized readily with formation of sludges and varnish-like deposits. Solvent extraction was found to be the only precise means of removing these readily oxidizable constituents to produce highly sludge-and varnish-resistant engine-lubricating oils. The success of the first two furfural solvent extraction plants at the McKean and St. Mary's refineries in accomplishing this objective led to the third installation at Emlenton.

After the basic features of the new plant were decided upon by the engineering department, Foster Wheeler Corporation was requested to prepare numerous detailed studies as to the most economic design. These included studies of fired heaters versus steam for the solvent-recovery systems and of the types of drives most suited for the numerous pumps and refrigeration compressors. After making utilities balances on several types of operation, the decision was made to install a new high-pressure-steam-generating plant with provision for the possible future installation of an electric-power-generating unit. Considerable study and planning was also required on the arrangement of the new plant equipment in the available site which was located on a restricted strip of land between a hillside and the Allegheny River.

While the final engineering and design work in




Flow diagram of lubricating oil solvent dewaxing plant.




Flow diagram of lubricating oil furfural refining plant.

the new plant was in progress, war was declared. While the need for high-quality heavy-duty and aviation oils and special waxes was recognized, the greater immediate demand on the petroleum industry was for 100-octane gasoline, toluene and butadiene. The priority situation accordingly demanded that every effort be made to utilize second-hand or reconstructed equipment wherever possible. Fortunately, Quaker State Oil Refining Corporation had some time previously purchased the solvent dewaxing plant of a refinery in process of liquidation. After considerable study, it was found possible to recondition and utilize the major portion of this old plant in the new construction program. Considerable of the tankage and miscellaneous equipment for the new plant was also secured by salvage and relocation of many items from other of the company's refineries. This extensive program of salvage and conversion of existing equipment by Foster Wheeler Corporation engineers resulted in the saving of several hundred tons of critical new materials and equipment.

Referring to the simplified flow diagram, it will be noted that the new dewaxing and recrystallization wax plant comprises seven major sections:

1. Direct expansion ammonia chilling.
2. Double pipe scraped surface exchangers and chillers for both the solvent dewaxing and the wax recrystallizing process sections.
3. Continuous vacuum dewaxing filters.
4. Tubular exchangers and chillers to chill wash solvents.
5. Flue-gas generation, circulation and chilling.
6. Four complete product recovery systems for:
   a. Dewaxed oil.
   b. Slack wax.
   c. Slop wax filtrate.
   d. Product wax.
7. Solvent-water separating and recovery system.

### Units in Parallel

The solvent dewaxing and wax recrystallization process section is essentially two separate units which may be operated in series or in parallel flow. Several combinations of operations may accordingly be carried out. Reduced wax distillate can be charged to the dewaxing unit to produce a neutral oil of —10° F. pour point. (This dewaxed neutral is subsequently extracted in the furfural refining process unit to yield a lubricating oil having a viscosity index of 110 to 115.) The "slack wax" from the dewaxing operation, averaging 125° F. melting point and containing about 6 percent oil, is simultaneously charged to the recrystallizing unit with additional solvent where at a filtering temperature of 30° F. it is deoiled to yield crystalline wax having a melting point of 130-132° F. AMP and an ASTM oil content of well under 1 percent. As an alternate operation, Pennsylvania cylinder stock may be dewaxed to 0° F. pour point, yielding a petrolatum of about 128° F. melting point, with about 8 percent oil content. This petrolatum may then be recrystallized with additional solvent at a temperature of 60° F., yielding a microcrystalline wax of a high melting point and an oil content of 0.5 percent or less.

The solvent dewaxing and recrystallization units are sufficiently flexible that cylinder stock can be dewaxed in the dewaxing unit while paraffine slack wax can be charged to the recrystallizing unit for production of finished crystalline waxes. Alternately, it is possible to process neutral oil in the dewaxing unit and at the same time to recrystallize crude petrolatum to yield micro-crystalline type waxes.

### Control of Pour Point

By selective control of solvent ratios and chilling temperatures it is possible to produce neutral oils having pour points from plus 25° F. to as low as minus 30° F., and viscous stocks having pour points from plus 25° F to as low as minus 20° F. Similarly, crude paraffine waxes can be solvent fractionated to yield oil-free crystalline waxes having melting points as low as 110° F. and as high as 140° F. Petrolatum can be recrystallized and fractionated to yield microcrystalline type waxes with melting points ranging from 110° F. up to 160° F. or higher.

The solvent dewaxing unit of the plant has a designed capacity of 1000 to 1500 barrels per stream day, depending upon the type of charge stock and the pour point to be produced. The wax recrystallization section has a designed capacity of 200 to 275 barrels per stream day, depending upon the type of crude wax charge and the type of product wax desired.

Average plant operating data are shown in Table 1.

The flow through the dewaxing unit is essentially as follows: The charge oil is mixed with solvent, the ratio depending upon the viscosity of the charge oil, and held constant by a ratio-flow recording controller. The mixture is first cooled by water in a shell-and-tube exchanger and then by cold dewaxed oil filtrate in several double-pipe-type exchangers. The partially cooled mixture passes through the inner pipe of the exchangers, wherein revolving spring-loaded scrapers keep the surface free of wax accumulation thereby assuring constant high heat-transfer rates. The charge mix is finally chilled to the desired filtering temperature by the use of direct-expanding ammonia in additional double-pipe, scraped-surface chillers. The cold mix containing the crystallized waxes then passes to a gravity-flow filter-feed tank where the amount of charge admitted to each filter is controlled by liquid-level instruments operating butterfly-type valves.

The liquid oil passes through the filter cloth of the revolving filter drums and is subsequently pumped from the filtrate receiver through the previously mentioned double-pipe exchangers, whereby considerable refrigeration is recovered, and then passes to a surge tank before it is charged to the solvent-recovery system.

The wax cake, commonly called "slack wax," collects on the surface of the revolving drums of the vacuum dewaxing filters, where it is continuously washed with cold solvent to displace oil held in the interstices of the wax crystals. The washed wax cake is continuously removed from the filter drums and pumped, by means of a reciprocating steam pump, through a heat exchanger where some refrigeration is recovered by transfer to incoming wash solvent. The wax cake is then heated by exhaust steam to a completely liquid state to aid in settling out in the surge tank any moisture that may have entered the filtering system.

The "slack-wax" mix may then be either charged to the recovery system for removal of the solvent or may be charged to the wax recrystallization unit for deoiling and fractionating. If the latter operation is followed, the wax is mixed with additional solvent to the desired dilution, cooled in a shell-and-tube heat exchanger with water, and finally chilled in a double-pipe heat exchanger to the desired filter-

ing temperature. The filtering temperature varies from plus 25° F. to plus 60° F. depending upon whether the slack wax is of a crystalline or amorphous character and also upon the desired final melting point of the product wax. The chilled wax mix is then processed through the recrystallizing unit in a manner similar to that already described for the dewaxing unit. The filtrate containing the oily and undesirable low-melting-point portion of the "slack wax" that has passed through the filter cloth is used to precool some of the wash solvent before being charged to the recovery section for removal of solvent. The product wax cake is heated to approximately 150° F. with exhaust steam to liquefy the wax before it is run through the recovery system.

### Steam for Removal of Solvent

The four recovery systems use live and exhaust steam for the removal of solvent. The dewaxed oil filtrate is preheated by solvent vapor and by countercurrent stripped dewaxed oil before being flashed at atmospheric pressure. In order to obtain maximum heat economy, a system of double-effect evaporation is employed. Steam stripping is used for removal of final traces of the dewaxing solvent.

The other three recovery systems for the "slack wax," the product wax and the oily or "slop wax" filtrate, use exhaust steam to evaporate off 75-80 percent of the solvent and then follow with live-steam reboiling to remove essentially all of the remaining solvent before final steam stripping of each stream. In these three sections, the evaporation is all carried out at atmospheric pressure since the quantities of solvent handled are not sufficiently large to justify a double-effect evaporating system. Since the flowing quantities of either of these three streams are relatively small, finned-tube heaters are used, heated with live steam, to aid in maintaining satisfactory temperatures at the base of the stripping columns. The net flow of product from the base of the stripper is level-controlled to storage, and pressure governors are used to aid in maintaining circulation of the stripper bottoms back through the reheaters.

### Reduced Furfural Requirement

The furfural refining unit is quite similar to the two units that were previously designed and constructed by Foster Wheeler Corporation for Quaker State Oil Refining Corporation in 1938-39. The main improvement has been in the design of the extraction tower in order to reduce the quantity of furfural required to yield the desired quality of product. This new tower is the first one of its kind installed and is the outgrowth of a study undertaken by the engineers of Texaco Development Corporation, Quaker State Oil Refining Corporation and the Foster Wheeler Corporation.

The tower contains eight nests of Raschig rings, each five feet in depth, with specially designed trays above each nest to assure even distribution of the down-flowing solvent, without interfering with the up-flowing refined oil or raffinate stream. By the use of two intercoolers to cool the descending stream of extract mix as desired, and regulation of the temperatures of the charge oil and treating solvent, a very even temperature gradiant is maintained throughout the tower. It is possible to vary at will the temperature in any part of the treating tower to obtain optimum results for any particular charge stock.

The untreated oil is preheated to the desired temperature by either hot furfural or exhaust steam and charged to the middle of the treating section of the extraction tower. The furfural, at a temperature ranging from 200° F. to 300° F., depending upon the stock being refined, is introduced just above the top nest of Raschig rings. The furfural flows downward through the oil-filled packing countercurrent to the ascending stream of charge.

The raffinate, together with a small quantity of solvent, flows from the top of the extraction column to a surge tank. The mix is pumped (controlled by a rate-of-flow controller) through a heat exchanger and direct-fired heater to the vacuum-flash and stripping column where all traces of furfural are removed from the refined oil.

The extract solution, containing most of the furfural solvent, flows from the bottom of the settling section of the treating tower to a surge tank before being charged to the recovery section. Since fuel costs are quite high, a double effect evaporation system is employed, together with a final steam stripper.

The furfural extraction unit was designed to charge from 1000 to 1750 barrels per day, depending upon the type of charge stock and the degree of extraction desired. Table 2 shows typical results of 10-day trial runs.

The plant was brought on stream in late September and after the usual "tuning up" period has been operating with complete satisfaction both as to quality of product and capacity.

**TABLE 1**

| | Reduced Wax Distillate | Extracted & Filtered Cylinder Stock |
|---|---|---|
| Charge Oil: | | |
| API Gravity | 32.7 | 27.7 |
| SSU Viscosity | 152 @ 100° F. | 136 @ 210° F. |
| Pour Point °F. | 90 | 70 |
| P.M. Flash | 430 | 530 |
| Dewaxed Oil: | | |
| Yield percent by volume | 79 | 88 |
| API Gravity | 30.4 | 27.2 |
| SSU Viscosity | 195 @ 100° F. | 146 @ 210° F. |
| P.M. Flash | 435 | 525 |
| Pour Point °F. | 0 to —5° F. | 10-15° F. |
| Color | 3D NPA | 2 TR |
| Carbon | .. | .95% |
| Slack Wax: | | |
| P.M. Flash | 430 | 520 |
| Melting Point (ASTM) | 126.5 | 129 |
| Percent Oil Content | 6.5 | 8.0 |

**TABLE 2**

| | Dewaxed Neutral Oil | Raw Cylinder Stock |
|---|---|---|
| Charge Oil: | | |
| API Gravity | 30.4 | 26.0 |
| SSU Viscosity | 195 @ 100° F. | 161 @ 210° F. |
| P.M. Flash | 430 | 525 |
| Percent Furfural Applied by volume | 159 | 160 |
| Treating Tower Temperatures: | | |
| Top °F. | 235 | 275 |
| Feed Tray °F. | 199 | 216 |
| Bottom °F. | 134 | 179 |
| Refined Oil Yield: | | |
| Volume percent | 92.0 | 94.0 |
| Refined Oil: | | |
| Gravity API | 32.9 | 27.3 |
| SSU Viscosity | 172 @ 100° F. | 151 @ 210° F. |
| P.M. Flash | 430 | 535 |
| Viscosity Index | 113 | 105 |
| Extract: | | |
| Gravity API | 7.8 | 5.8 |
| SSU Viscosity | 85 @ 210° F. | 3100 @ 210° F. |

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# Combustible Gases As Substitute Motor Fuels

GUSTAV EGLOFF and MARY ALEXANDER*
Universal Oil Products Company,
Chicago, Illinois

WITH increasing demands for petroleum made by the armed forces, it has become more and more necessary in European countries to resort to substitute motor fuels. Combustible gases of various types are being used extensively for this purpose. In consideration of the peace to come, the available facts about these fuels should be examined to find what possibilities they offer.

The gases used include the lower-paraffin hydrocarbons, methane, ethane, propane, n-butane, and isobutane as well as acetylene, hydrogen, ammonia, and various combinations of these. Gases of mixed and variable composition, such as city gases and sewage gas also are utilized.

The combustible gases used in Europe are estimated to have replaced over 3,000,000 barrels of gasoline in 1943. In Germany, about 100,000 of the 400,000 commercial vehicles still in operation, run on hydrocarbon gases.[1] For supplying the various gases, 700 or more filling stations are functioning in that country. In the rest of Europe there are probably 40,000 more vehicles operating on these types of substitute fuels. In the United States, particularly in the Far West, 2,000,000 barrels of propane and the butanes are used annually in about 25,000 buses, trucks, and other heavy-duty vehicles.

Methane, ethane, propane, and butanes are also used satisfactorily to operate railway locomotives. Airplanes will run on these substitutes, but at the present actual use is impractical.

The gaseous substitutes are marketed in liquefied form and also in gaseous form at low and high pressures. Low-pressure gas is pumped from the city mains or gas tanks into balloons on the tops of vehicles. High-pressure gas and liquefied gas are distributed in two ways. Metering units much like those used for gasoline measure the gases into high-pressure fuel tanks, or they are marketed in prefilled alloy steel cylinders which are carried in racks attached to the vehicles. This procedure has given rise to the popular term, "bottled gas." Germany distributes compressed and liquefied gases for motor fuel use by both of these methods, whereas in the United States permanently installed fuel tanks are used almost entirely.

*Presented before the Division of Petroleum Chemistry and the Division of Gas and Fuels at the 107th Meeting of the American Chemical Society, Cleveland, Ohio, April 3 to 6, 1944.

### Equipment

The bags used for low-pressure gas are large fabric balloons installed on the tops of vehicles. Gas bags hold so little that they are not practical for traveling long distances, and they deteriorate after a year or so if exposed to the weather. The life of the bags may be lengthened by housing them in box-like structures. About the only advantage over compressed and liquefied gas to be gained by their use is the conservation of critical materials. In European countries, the bags are used considerably for city gas, sewage gas, and methane.

The cylinders vary in construction with the kind and amount of gas used and whether it is compressed as a gas or liquefied. When high pressures are used the cylinders are necessarily heavy and add more to the weight of the vehicle than does a gasoline tank. The development of light-weight alloy cylinders has partially removed this objection, but even the new cylinders are heavier than is desirable. Because propane and the butanes liquefy under less pressure than the other gaseous fuels, lighter weight containers may be used. In view of this fact and their comparably good or better engine performance over other gaseous substitutes, propane and the butanes are more desirable than the other gases. In Europe, however, methane, city gas and sewage gas are much more abundant than propane and butanes, and therefore have been used more widely.

The use of combustible gases as motor fuels has been limited by a shortage of steel and other critical materials for

cylinders, pressure regulators, piping, and gas compressors in countries where the gases themselves are plentiful. Fuel tanks permanently attached to the vehicles conserve steel since many portable cylinders are required for continuous operation of one vehicle. Italy, for example, had an estimated stock of 75,000 cylinders in 1941, but only 7500 of these were in actual use in cars at one time.[35] The remainder were in the process of being filled or transported. Since an average of 10 portable cylinders must be allotted to each vehicle for continuous operation, many thousands more would be necessary to keep Italy's entire motor fleet on the road. As a consequence of cylinder shortage, Italy was forced to curtail extensive plans for the use of methane as motor fuel. The other European countries, like Italy, must solve the steel problem before the gases can be widely used as substitute fuels.

The conversion of a gasoline-driven vehicle to run on gases involves some changes in the engine and fuel system in addition to provision of storage facilities. Special designs of carburetors, heat exchangers, and pressure regulators should be installed. Supply lines must be made from heavier materials than are necessary for a gasoline-driven vehicle. All the mechanisms involved in supplying gases to the motor must be absolutely tight since they are under pressure, and leakage may set up fire or explosion hazards, particularly in a closed garage. The danger is greater with methane and city gas, since higher pressures are used, than with propane and butanes. When the gases are liquefied, another hazard is encountered since exposure of the skin to evaporating fuel causes freezing. Because of the added weight of this special equipment, the gases are more satisfactory for use in buses, trucks, and tractors where the weight is of less importance, than in passenger cars.

### General Comparison with Operation on Gasoline

In order to operate with gases under conditions of maximum efficiency, specially designed high-compression engines are necessary. When vehicles built to run on gasoline are converted to operate on gas, the engine efficiency increases in proportion to the amount of conversion made. The heat value of gases per volume is lower than that of gasoline, but this effect can be partially compensated for by operation at increased compression ratios. Another compensating factor is that almost complete combustion can be obtained with the gases. The better combustion lessens carbonaceous deposits, and consequently, maintenance costs are cut. Less dilution of crankcase oil and lower consumption of lubricating oil result in additional savings, and a lighter grade of oil may be used. The composition of the exhaust from the gaseous fuels is less objectionable than that from liquid fuels. Absence of unpleasant odors is a particularly desirable feature in the operation of buses. Heavy exhaust smokes, given out by some diesel engines, are not emitted by gas-burning motors.

One of the principal disadvantages encountered by users of gaseous fuels is the absence of filling stations. Although there are many of these in existence, they are sparsely located both in the areas of Europe and on the West Coast of the United States where the gases are being used. Another difficulty arises from the lack of general knowledge about handling and proper care of equipment. Every driver needs to have good mechanical sense in order to operate a gas-propelled vehicle at maximum efficiency.

### Methane and City Gas

Many countries used methane and city gas as substitutes for gasoline before the present war began, because they were available from domestic sources. Methane is obtained from natural gas, and gases from petroleum refining, coal hydrogenation, Fischer-Tropsch hydrogenation of carbon monoxide, coal carbonization, coal mining, and the fermentation of city sewage. City gas, also called town or illuminating gas, is the gas normally used for heating and cooking purposes both in the United States and abroad. This gas, as supplied in European cities from high-temperature coal carbonization, usually contains about 20 percent methane along with other paraffins, olefins, hydrogen, carbon monoxide, carbon dioxide, oxygen, and nitrogen, and is used for motor fuel as supplied through the mains. The sources of methane in different countries vary widely. Germany has access to all sources. Italy has stimulated methane production from natural-gas fields and coal carbonization units. Switzerland is producing methane from sewage. Although there has been no indication of its extensive use as motor fuel, large potential supplies of methane are available in the natural-gas and oil fields of Rumania, Poland, Hungary, Austria, and Czechoslovakia. Russia has made some use of methane for motor transport. Her potential sources include extensive natural-gas and oil fields, petroleum refineries, coal-carbonization units, coal mines, and sewage plants. In England, coal mines, coal-carbonization units, and sewage plants are the principal sources. In the United States practically no use has been made of methane as a motor fuel since gasoline supplies are available and the performance given by methane does not compensate for the inconvenience and costs involved in its use at the present time. A permit was issued, however, to a man in Massachusetts to operate buses on refinery or city sewage gases.[7]

The actual production of methane is not necessarily indicative of the potential supplies. Italy allocated about 50 percent of her methane production to motor-transport use at the beginning of the war. This percentage decreased somewhat, but actual production for motor fuel increased from 56,500,000 cubic feet in 1937 to 296,630,000 cubic feet in 1941.[20, 28] Switzerland has comparatively meager supplies of all fuels, but in Zurich alone about 30,000,000 cubit feet of methane per year, which is used to run 40 garbage trucks, is available from the sewage plant.[26] In England it has been estimated on the basis of 0.9 cubic feet per capita a day, that 50,000,000 cubic feet of gas a day would be available from sewage.[64] This amount would replace 4,130,000 barrels of gasoline per year. From the mining of coal in England, 1000 cubic feet of methane per ton could be obtained and this supply would replace 47,620,000 barrels of gasoline annually.[14] These quantities, however, are not being produced since other factors limit the practicability of such measures. A closed-down coal mine in Tasmania is estimated to contain enough methane to replace over 217,000 barrels of gasoline annually for the next sixty years.[7a] The potential supplies in Rumania are relatively high when one considers her annual natural-gas production, estimated at about 16,000,000,000 cubic feet in 1942.[20b]

The number of vehicles using methane has increased markedly since the war began. In Italy, 771 were operating on methane in 1939.[18] By 1941, 20,000 had been converted, but it is doubtful that more than 8000 were actually being used to any extent.[35] The Germans were operating about 22,000 vehicles on methane in 1940.[65] England had only 109 methane-propelled vehicles by 1943.[20a] Trucks and buses are the principal users; however, the engines of trains are utilizing this fuel also. Italy reports operation of 120-horsepower locomotives on methane.[23] These locomotives have a maximum speed of 60 miles per hour and operate over a radius of 300 miles.

The number of vehicles actually running on city gas today cannot be estimated with any degree of accuracy. Germany's 1943 motor fleet has been estimated to include thousands using compressed city gas. In England, 1438 were registered to use gas in 1943.[20a] In Paris alone, 500 buses have traveled more than 12,000,000 miles on low-pressure city gas.[30] Even Russia with large gasoline supplies, makes use of this fuel. In the state of Victoria, Australia, in 1943, 50 trucks were operating on city gas.[71]

The growth of methane and city-gas motor fuel was marked in Germany by the appearance in 1935 of filling stations to supply these gases in both compressed and uncompressed form. By 1937, Germany had one or more stations selling compressed methane or compressed city gas in 43 cities.[53, 54] It is estimated that there were 50 such stations in western Germany alone in 1943.[35] Italy had 60 distribution centers for compressed methane in 1939.[41] Fourteen compressor stations were in operation or under construction in Belgium by 1941.[46] London had 80 such filling stations in 1940.[36] The Russians planned to complete the construction of 100 filling stations by 1942. They are also being operated in France, Austria, and Australia. In addition to filling stations another means of refueling is available, a portable station which makes possible the use of city gas in outlying districts. A typical example of such equipment is a truck that carries 12 steel cylinders holding about 60,000 cubic feet of gas under 5000 pounds pressure.[66] This volume of gas can supply about 20 average fillings.

Low-pressure gas is stored in bags on the roof of the vehicle at a pressure not exceeding 0.072 pounds per square inch.[61] These bags are made of two plies of cotton fabric which are rubberized and cemented together. This type of conversion can be made without changes in engine equipment, and the vehicle may run alternately on gas or gasoline. Since the capacity of the bag limits the cruising range to about 20 miles with city gas and less than 50 with methane, high-pressure utilization has been preferred where possible.

When methane or city gas is to be used at high pressures it is either supplied in portable alloy steel cylinders under

3000 to 5000 pounds pressure or introduced into a tank permanently installed on the vehicle. Alloys such as chrome-molybdenum, nickel-chrome-molybdenum, and aluminum-magnesium are used for cylinder construction. In Italy the chrome-molybdenum alloy is more popular because it is less expensive, but the aluminum-magnesium is lighter in weight.[26] When compressed gas is used, two pressure-reducing valves to lower the pressure first to about eight pounds and then to slightly under atmospheric pressure for engine intake are needed.[61]

The average methane cylinder requires about 100 pounds of steel for construction. Usually at least two methane cylinders, each having a capacity equivalent to 2 to 2.5 gallons of gasoline, are in use on the vehicle at one time. When city gas is used, the equivalent of one gallon or less of gasoline is contained in a 100-pound cylinder.[62]

The composition of a typical city gas is $CH_4$, 21.1 percent; $C_2H_6$, 0.7 percent; $C_3H_6$, 2.6 percent; $CO_2$, 2.3 percent; CO, 10.8 percent; $O_2$, 0.6 percent; $H_2$, 54.4 percent; $N_2$, 7.0 percent.[26] Some gases contain cyanides which corrode the containers when the compressed fuel is used, but processes for removing them have been developed. Ordinary European city gases have heating values of about 500 Btu per cubic foot. About 250 cubic feet of gas is reported to give the same performance as 1 gallon of gasoline.

The heat value of liquid methane, 52,000 Btu per gallon, is lower than that of gasoline which is around 119,000 Btu per gallon. In engines specially designed for using methane, 100 cubic feet is equivalent to 1 gallon of gasoline, but the equivalent is 140 cubic feet in engines designed for gasoline.[78]

The octane number of methane is over 100.[78] Other properties of methane, and of ethane which is often present along with methane, are shown in Table 1.

**TABLE 1**[23]

| | M.P. °C. | B.P. °C. | Critical Temp. °C. | Critical Press. Atm. |
|---|---|---|---|---|
| Methane | —186 | —160 | —82 | 55 |
| Ethane | —172 | — 93 | 34 | 50 |

The over-all engine efficiency of either city gas or methane is highly dependent on the design of the engine. The higher octane number of methane partially compensates for its lower heat values when compared with gasoline. The power output of both methane and city gas is higher when the compression ratios are increased. A compression ratio as high as 16:1 can be used with these gases.[78, 84]

The brake thermal efficiency of city gas is about 85 percent that of gasoline in an engine having a 5:1 compression ratio without supercharging.[27] The loss is 5 to 10 percent greater with the small high-speed engines of passenger cars and small trucks than with the larger slow-running engines of trucks.[61] Table 2 shows the comparative performance of a 7-horsepower engine on gasoline and city gas with and without supercharging.

**TABLE 2**[24]

| FUEL | Max. Speed R.P.M. | Max. B.H.P. | Ratio-Max. Output On Fuel: Max. Ouptut Using Gasoline | FUEL CONSUMPTION: Gas C. Ft./ Hour | Gas C. Ft./ B.H.P. Hour | Gasoline Lbs./ Hour | Gasoline Lbs./ B.H.P. Hour | Brake Thermal Efficiency Percent |
|---|---|---|---|---|---|---|---|---|
| **Supercharging** | | | | | | | | |
| Gasoline | 3250 | 24.8 | Percent 100 | .... | .... | 19.7 | 0.795 | 16.15 |
| City Gas | 2846 | 17.9 | 72.3 | 488 | 27.21 | .... | .... | 19.35 |
| **Non-Supercharging** | | | | | | | | |
| Gasoline | 2313 | 11.2 | 100 | .... | .... | 6.36 | 0.568 | 22.6 |
| City Gas | 1916 | 7.4 | 66.1 | 199.5 | 27.0 | .... | .... | 19.6 |

Since methane is derived from sources which were not normally utilized except for heating, the price of raw material is relatively low. In Germany, on the basis of equivalency to a gallon of gasoline, it was marketed at 41 cents.[5] The cost of this fuel varies widely with the source and amount of processing required. Gas-bag equipment for use of methane at low pressures is reported to cost about $120 to $140 for an 8-horsepower auto in England.[13] For use at high pressure, the cost of changes necessary has been estimated at $150 to $300.[5] In Italy, conversions cost about $210 but increased to $390 in 1941 because of equipment shortages.[35]

The comparative costs of city gas and gasoline cannot be measured in quantitative terms since the available data are based primarily on operations before the war. The prices of fuels vary from country to country. Generally speaking, in countries which import their petroleum supplies, the retail price of gas is considerably less, while in countries such as Russia, with vast domestic supplies of both gas and gasoline, the comparison must be made on a cost-performance basis. A report from Moscow stated that the cost of running two trucks on gas proved to be twice as high as with gasoline, but the observations indicated that certain improvements could be made to provide for economical operation on city gas.[80] In England the price of gasoline was about 50 cents per gallon, during the early part of the war, while an equivalent amount of compressed gas cost about 25 cents and low-pressure gas about 15 cents.[82] Two years before the war, gasoline was 49 to 58 cents per gallon in Germany while an equivalent of city gas cost about 35 to 40 cents.[83] A conversion to compressed gas, complete with efficient engine equipment was estimated at $410 in 1942 in an English report.[61] The cost of conversion varies according to type of vehicles and extent of changes.

If driven by necessity to use methane as motor fuel, the United States could doubtless make the change. We have ample sources in natural gas, petroleum refining, coal, and sewage. Enormous volumes of methane are potentially available to the United States from these sources. The equivalent motor fuel quantities in barrels of gasoline available annually from various sources in this country, if all were used for that purpose, are shown in Table 3.

**TABLE 3**

| SOURCE | Barrels of Gasoline Equivalent to Methane |
|---|---|
| Natural gas | 833,000,000 |
| Petroleum refining | 143,000,000 |
| Coal Mining | 143,000,000 |
| Coal Carbonization | 36,000,000 |
| City sewage | 6,000,000 |
| Total | 1,161,000,000 |

The total is roughly twice the actual peacetime consumption of gasoline which was 694,600,000 barrels in 1941.[22]

### Propane and Butanes

The principal sources of propane, n-butane, and isobutane are natural-gas and oil wells, petroleum refining, gases from coal hydrogenation, Fischer-Tropsch carbon monoxide hydrogenation, and low-temperature coal carbonization. The relative percentages of propane and butanes in petroleum and natural gas vary according to the source. Germany derives most of her supplies from the processing of coal. As much as 10 percent of the output of coal and carbon-monoxide hydrogenation is propane and butanes. The United States obtains these products from petroleum and natural gas. Russia also produces large quantities from oil and natural-gas wells and from refining crude oil.

The fuels actually marketed for use in internal combustion engines are propane, butanes, and their mixtures. One mixture, commonly used before World War II, contained 50 percent n-butane, 30 percent isobutane, and 20 percent propane by volume.[62] This particular fuel mixture has an octane rating of at least 100. The octane number can be raised by increasing the percentage of propane. Greater amounts of propane are added in winter than in summer. At the present time all available isobutane is being used in alkylation processes to produce aviation gasoline, and large volumes of n-butane are used in isomerization and dehydrogenation processes for aviation gasoline production.

Germany's annual production of liquid propane and butanes is probably over 2,400,000 barrels. In the United States, 15,120,000 barrels were marketed in the form of liquefied petroleum gases in 1943,[72] whereas 10 years ago the volume was 937,880 barrels.[73] It was estimated that over 1,950,000 barrels of propane, butane, and their mixtures were used as motor fuel in 1943.[39] The balance of propane and butane in liquid form was used for domestic and industrial purposes.

Germany has encouraged the use of liquefied propane and butanes as a substitute for gasoline since 1935 by offering a tax relief of 50 to 75 percent.[40] In October, 1939, all buses carrying 16 or more passengers, except those operating in

smaller towns where distribution was difficult, were ordered to use liquefied hydrocarbon gases.[31] Germany had 40,000 motor vehicles running on liquefied propane and butanes in 1941.[76] In Budapest, Hungary, 500 to 600 taxi cabs were operating on propane and butanes.[27] In Russia many tractors and trucks use this fuel, particularly near oil fields where large quantities are available. England has not used these to any extent; by 1943, only 12 vehicles were registered as operating on them.[30a]

There are about 25,000 trucks, buses, and heavy-duty engines operating on propane and butanes in West Coast areas of the United States. The government has recently tightened restrictions on use of liquefied gases because large quantities are needed to meet military and essential civilian demands.[12a] Motor-fuel consumption had reached 3,000,000 gallons during the first two months of 1944 in California alone. In order to avoid rationing, many passenger cars had been converted to use liquefied gas at a cost of $1000 compared to the prewar cost of about $150.[30b] A few year ago there were about 65 filling stations in 6 West Coast states.[97] One or more stations are operating in all large cities of California. In the state of Washington 200 buses have been registered as liquefied-gas consumers, and the entire bus system of Spokane uses this fuel. The number of trucks licensed as propane-butane users in 1942 is shown in Table 4.

**TABLE 4**

**Trucks Using Propane and Butanes**

Statistics supplied by several state governments and the American Petroleum Institute, except the data for California which were given by C. L. Parkhill.

| | |
|---|---|
| California | 15,000* |
| Texas | 850 |
| Nevada | 487 |
| Oklahoma | 269 |
| Washington | 260† |
| Arizona | 187 |
| Missouri | 150 |
| Kansas | 127 |
| Louisiana | 125 |
| Arkansas | 119 |
| New Mexico | 118 |
| Mississippi | 100 |
| Minnesota | 69 |
| Utah | 47 |
| Oregon | 31 |
| Colorado | 24 |
| Indiana | 18‡ |
| South Dakota | 15 |
| Florida | 4 |
| Tennessee | 1 |

* Estimated total internal combustion engines by C. L. Parkhill. 7,500 of these are trucks.
† 200 buses and 20 passenger cars are included.
‡ This figure probably is not complete.

Propane has been found an excellent fuel for propelling locomotives. The Union Pacific Streamliner, the "City of Salina," has been operated on this fuel for some time. Propane has been found adaptable to both heavy-duty switch engines and small locomotives. In addition to efficient locomotive operation, propane can be used to meet other needs in comfortable and efficient rail transportation such as refrigeration, the cooling and heating of passenger cars, and cooking in diner kitchens.

Liquefied propane and butane gases are adapted to use in airplane engines but are not used to any extent. A Californian who operated his plane on propane-butane gas reports several advantages in performance and cost.[77] The heavy fuel tanks required for liquefied gas, however, detract from those advantages and the only practical use yet found in aviation is in experimental work on high-compression engines.

The cylinders for propane and butanes are made of a lightweight alloy steel, and the typical standard small bottle, with a capacity equivalent to 10.7 gallons of gasoline, weighs 86 pounds empty while the large bottles with capacity equivalent to 14.9 gallons of gasoline, weigh 117 pounds empty.[49] The standard pressure of the liquid fuel in these bottles ranges from 44 to 176 pounds per square inch. The length is about 5 feet for the large bottles, 4 feet, 4 inches for the small, and the diameter of either is about 1 foot. The cylinders are usually clamped on the side of the vehicle but may be mounted transversely beneath the body.

Suitable permanent fuel tanks with proper filler valves and internal and external pressure control are now on the market. These tanks may have a capacity of 25 gallons or higher and can be designed for pressures high enough so that propane alone can be used.[53] Some of these tanks are built with separate vapor drums inside the main tank. These drums are connected so that the required outage space is automatically provided for, and all need for testing the liquid level is eliminated.

With proper carburetion these fuels can be made to undergo practically complete combustion. There are two general types of carburetors available to liquefied-gas users. In one type the air-fuel mixing is accomplished by the variable orifice principle but most of those in use operate on the venturi principle which characterizes gasoline carburetors.[83]

The properties of propane and butanes may be seen in Table 5. The properties of motor gasoline are given as a basis for comparison.

**TABLE 5**

| | B.P. °C. @ 1 Atm. | Crit. Temp. °C. | Crit. Press. Atm. | Vapor Pressure 37.6° C. | 15.5 D15.5 | Btu./ Lb. | Btu./ Gal. | Octane No. |
|---|---|---|---|---|---|---|---|---|
| Propane | —42.1 | 96.8 | 42.0 | 190 | 0.508 | 21,668 | 92,000 | 100+ |
| n-Butane | — 0.5 | 152.0 | 37.5 | 52 | 0.584 | 21,334 | 104,000 | 91 |
| Isobutane | —12.2 | 134.0 | 36.1 | 76 | 0.563 | 21,334 | 100,000 | 99 |
| Gasoline | (a) | .... | .... | 12(W) 8(S) | 0.735 | 19,500 | 119,000 | 72(b) |

(a) Regular grade; initial and end B. P. 20-204 °C.
(b) The octane number of 1942 gasoline was 76 but because of wartime needs has been cut to 72 in 1944.
(w) Winter).
(s) (Summer).

Since the heat value per gallon of propane and butane is less than that of gasoline, lower mileage is to be expected, but the higher octane rating at least partially offsets this effect along with good carburetion, distribution, and almost complete combustion. Different opinions have been advanced as to the over-all results. Claims have been made that the mileage is as good and in some cases even better when propane and butanes are used to operate trucks which have been properly equipped.[55, 76]

Many road tests indicate less mileage per gallon than with gasoline. Table 6 shows the results of operating trucks with two liquefied-gas blends and gasoline of several grades. The liquefied-gas blends used were summer grade, 80 percent butane and 20 percent propane, and winter grade, 50 percent butane and 50 percent propane.

**TABLE 6[54]**

| Make of Truck | 50-50 Blend Mi./Gal. | 80-20 Blend Mi./Gal. | Total Operation All Blends Mi./Gal. | Gasoline Mi./Gal. |
|---|---|---|---|---|
| C. J. Mack | 2.20 | 2.28 | 2.22 | 3.62 |
| C. J. Mack | 2.56 | 2.68 | 2.64 | 2.67 |
| C. J. Mack | 2.49 | 2.63 | 2.70 | 3.18 |
| C. J. Mack | 2.35 | 2.15 | 2.38 | 3.35 |
| 642 White | 2.45 | 2.77 | 2.62 | 2.64 |
| Average of trucks | 2.41 | 2.50 | 2.51 | 3.09 |
| Average based on total fuel and total miles | .... | .... | 2.55 | 3.03 |

Table 7 shows a comparison of operations on gasoline and on propane alone.

**TABLE 7[85]**

| Road Load Speed in Miles Per Hour | Gasoline Used at 6.1 Compression Ratio Mi./Gal. | Propane Used at 7.5 Compression Ratio Mi./Gal. | Ratio of Propane to Gasoline Percent of Mileage |
|---|---|---|---|
| 10 | 14.3 | 11.2 | 78.3 |
| 20 | 15.0 | 9.8 | 65.3 |
| 30 | 12.0 | 9.7 | 80.8 |
| 40 | 9.5 | 8.4 | 88.4 |
| 50 | 8.0 | 6.4 | 80.0 |
| Average | 11.8 | 9.1 | 77.1* |

* Based on the ratio of 9.1:11.8

The data in Table 7 show a comparative mileage of 11.8 for gasoline with 9.1 for propane or about 77 percent that of gasoline. On the basis of the heat values, however, only 73.5 percent of the gasoline mileage would be expected. So much depends on proper engine adjustments that a comparison on the miles per gallon basis involves many factors, and quantitative conclusions are hardly justified.

One of the definite advantages of propane and butanes is their relatively high octane rating. Propane has an octane number of over 100, n-butane 91, and isobutane 99. Because of these relatively high octane numbers, a compression ratio of 9.95 for propane and 6.75 for butane can be used,[52] while the compression ratio permitted by regular gasoline averages 6. If the compression ratio is not increased for operation

**TABLE 8[16]**
**No Change in Compression Ratio**

| Vehicle | Load Capacity Tons | MILES PER GALLON | |
|---|---|---|---|
| | | Gasoline Blend | Propane-Butane Blend |
| Bussing | 4 | 6.7 | 4.7 |
| Ford "BB" | 2 | 11.2 | 8.6 |
| Ford V-8 | 3 | 10.4 | 6.9 |
| Henschel | 3 | 8.5 | 5.6 |
| Henschel | 5 | 6.4 | 4.3 |
| Krupp (Air Cooled) | 2.5 | 13.8 | 10.4 |
| Krupp | 3 | 9.6 | 6.3 |
| Krupp | 3.5 | 8.7 | 6.0 |
| Mercedes | 5 | 5.7 | 3.6 |
| Opel "Blitz" | 3 | 10.2 | 7.0 |
| Vomag | 5 | 6.6 | 4.5 |
| Vomag | 6.5 | 3.7 | 2.5 |

with propane and butanes, much poorer mileage is obtained. Table 8 shows the comparative mileage with several types of vehicles when the compression ratio was not changed.

With increased compression ratio the mileage is almost equal to that of gasoline as shown in Table 9.

A truck operating on gasoline normally changes oil every thousand miles or so. With liquefied gases, oil change is usually necessary only after 3000 to 5000 miles and in some cases trucks have run up to 15,000 miles without change.[16]

Liquefied propane and butane gases offer other possible advantages to buses and trucks since they can be used for purposes in addition to engine fuel. The air conditioning of buses is one of these advantages. Many trucks haul loads of perishable food items which require refrigeration, and the cooling is accomplished with the same fuel which runs the engine. Trucks are designed so that the gas first cools the refrigerator compartment and then passes on to the engine. This system means low-cost refrigeration.

The advantages and disadvantages of propane and butanes as compared with gasoline are dependent upon their relative costs. The cost of propane-butane must be enough lower than gasoline to compensate for the necessary changes in fuel tank and engine equipment. Although taxes are eliminated or greatly reduced for substitute fuels in foreign countries, the tax per gallon for gasoline and liquefied gas is the same in the United States; thus savings can be gained only if the price of the fuels before taxation is considerably lower than that of gasoline. Passenger cars do not travel far enough to gain from the conversion but trucks and buses are operated in certain areas to definite advantage.

### Acetylene

Acetylene gas is used as a substitute for gasoline both alone and dissolved in substances such as ammonia, alcohol, acetone, and benzene. As early as 1900 this fuel was suggested for automobiles but practical use was not made of it because it forms a highly detonating mixture in engine cylinders.[8] Enough had been learned about internal-combustion engines and the chemistry of fuels by the outbreak of the present war so that acetylene could be used as motor fuel. Reports of practical operation on acetylene and its mixtures have come from France, Switzerland, and Italy. Dr. A. G. Claude, inventor of neon lights, is particularly active in this field.

Acetylene has a heat value of 20,880 Btu per pound which is comparable to that of gasoline.[35] The octane number, however, is less than 40.[21a] The power output of pure acetylene is only 25 to 30 percent that of gasoline, but it can be increased by the addition of other substances.[21a] Tests with an acetylene-ammonia mixture showed that on full load 45 horsepower was developed as compared with 50 horsepower from gasoline.[20] Acetylene damped with water alone gives up to 50 percent the power obtainable from gasoline, and with water and alcohol, as high as 85 percent of the power in small engines, and 75 percent in large engines is obtained.[21a] The maximum speed is 10 percent less than when gasoline is used, but starting and acceleration are as good as with gasolines.[8] Relatively lean fuel-air mixtures must be used to prevent premature ignition and knocking.

Acetylene and its mixtures differ from paraffin gases in that crankcase oil must be drained even more frequently than with gasoline.[21a] Carbonaceous deposits are greater than with gases. Another difference from the previously discussed gases is the fact that acetylene is better adapted to small engines than large. Although no disastrous explosions have been reported, extreme precaution must be observed to prevent them. Drivers are advised to leave acetylene-propelled cars in the open air for one hour before housing them for the night.

Two general methods permit the use of acetylene. In one method, a gas generator installed on the vehicle produces acetylene from water and calcium carbide. The acetylene gas, as such, or mixed with other substances is carburetted. In the other method, acetylene dissolved in substances such as liquid ammonia, is stored in cylinders or fuel tanks on the vehicle. The latter method is not so popular because the price is high and there is a shortage of high-pressure containers.[21a]

Several types of generators have been devised. One operates on the principle of dropping calcium carbide into water and the others drip water over the calcium carbide.[21a] The carbide-into-water principle prevents post-carburetion but difficulties are involved in measuring the amount of carbide dropped. Three general varieties of generators which drip water over carbide are used. The basket type carries carbide in a basket which is enclosed in a cylinder. The basket is raised and lowered for treatment with water as the pressure of the gas changes. The drawer type consists of a cylinder filled with calcium carbide. Water is pumped from the gasoline tank and fed dropwise to the carbide chambers. In the dry production type a drum with perforated walls is used. Water is fed into this drum through a hollow pivot. Because the water is delivered in exactly determined amounts, a fairly constant pressure is maintained by this method. It is probably the best generator from a technical point of view but it is large and cumbersome.

The equivalent of 1 gallon of gasoline, when acetylene generators are used, is 6 to 9 pounds of calcium carbide and 0.15 to 0.2 gallon of alcohol.[21a] The drawer-type generator manufactured by General Motors Corporation carries the equivalent of six gallons of gasoline.[8] Ammonia and acetylene are used satisfactorily in a ratio of 78:22.[10] Enough of this mixture has been carried to permit an automobile to travel 372 miles without refueling.

The cost of converting gasoline engines to operate with acetylene generators or prefabricated acetylene mixtures varies. Recent estimates from Switzerland on acetylene generators and other engine alterations range from $365 to $400.[21a]

While recognizing the value of acetylene and ammonia as a motor-fuel mixture, Dr. Claude emphasizes that its wide adoption in France is almost prohibited as there is a serious shortage of coal and ammonia. The derivatives of the latter have to be reserved mainly for agriculture.

### Hydrogen and Ammonia

Several other gases can be used in compressed and liquid forms to run internal-combustion engines. These gases have not been substituted for gasoline on a large scale in Europe because they are used for other purposes and little research on their performance has been conducted. Reports from France, Italy, and Germany show some actual use of hydrogen, ammonia, their mixtures, hydrogen with oxygen, hydrogen with oil, and ammonia with ethane. In Germany, 3000 to 4000 commercial vehicles operate on hydrogen and the Berlin-Hanover express has been run by hydrogen engines for several years.[33]

Hydrogen can be used for operating gasoline engines and modified diesels. Pre-ignition was experienced with hydrogen at a compression ratio of 3.8 but pre-ignition was avoided even at a compression ratio of 7.8 when the indicated mean effective pressure was maintained below 74 pounds per square inch.[30] When used in a modified diesel, the hydrogen permits use of lower grade oil than when oil is used alone.[30] The problems of large-scale and low-cost production and transportation of hydrogen must be solved before wide use can be expected.

An interesting example of hydrogen-and-oxygen-propelled motors has been noted in a Nazi U-boat captured by the Allies.[4, 28] This boat is driven on the surface by alternative-fuel engines running on oil. These engines drive a small high-speed dynamo, delivering its current to a high-pressure electrolyser which dissociates water into hydrogen and oxygen under a pressure of 3000 to 5000 pounds per square inch. These gases are stored in light-weight high-pressure

**TABLE 9[32]**
**Change in Compression Ratio**

| Vehicle | Gasoline Standard C.R. | | Standard C.R. | Liquefied Gas High C.R. | | High C.R. |
|---|---|---|---|---|---|---|
| | BHP | Mi./Gal. | | BHP | Mi./Gal. | |
| White Bus | 80 | 3.6 | 4.75:1 | 108 | 3.4 | 5.9:1 |
| Hercules Bus | .. | 3.5 | 5:1 | ... | 3.3 | 7:1 |

cylinders along the keel, and when the submarine dives, the engines are switched over to run on hydrogen and oxygen. The steam which results from the combustion of these gases is put back into the engine at a temperature slightly above the saturation point. Required volumes of hydrogen and oxygen in a 2:1 ratio are injected into each working cylinder separately. The cylinder is then filled with steam and the mixture is fired by means of a spark. From the reaction of hydrogen and oxygen, heat is generated, and the steam expands and drives the piston.

The system of this boat, called the Erren, was naturally subjected to considerable research.[4, 35] Application of this principle to a submarine increases the radius of action to more than 15,000 miles. Because the usual electric motors and batteries are not necessary, there is more available space for armaments. The saving in weight permits the pressure hull to be strengthened so that the submarine can crash-dive at steep angles and safely submerge to a depth of 600 feet, which is far below the depth possible with the usual electric motors. The poisonous gases sometimes generated by the batteries which operate electric motors are also eliminated. In case of disaster, the oxygen stored would enable the crew to live a few weeks. The quantity of hydrogen would be more than sufficient to blow water out of flooded compartments, and the submarine would then automatically rise to the surface.

Ammonia has been used as a motor fuel.[34] A test run showed that a consumption of 2.65 pounds of ammonia is equivalent to 1 gallon of gasoline.[57] Ammonia is decomposed by a catalyst into nitrogen and hydrogen. The hydrogen of the mixture oxidizes in the motor to furnish the power.

Ammonia also is mixed with hydrogen for motor-fuel use. A typical mixture contains 1 part of ammonia to 1.5 parts of hydrogen by volume.[70] This combination can be used at a compression ratio higher than that for gasoline. Ammonia is also used in combination with liquid ethane at 2200 pounds per square inch or compressed gaseous ethane at 440 pounds per square inch.[68]

Research on hydrogen, ammonia, and various combinations has not been sufficient to contribute much to the development of these gases as motor fuels.

## Summary

Since abundant sources of methane, ethane, and to a far lesser extent, propane and the butanes are available in many parts of the world, their use in internal-combustion engines will undoubtedly continue after the war. Research and actual use have proven their practicality in the operation of motor vehicles. The future of acetylene, ammonia, and hydrogen as motor fuel is indefinite.

The most disadvantageous features of using the paraffin gases are the heavy weight of equipment required, the hazards involved, and the scarcity of filling stations. As interest in these fuels continues, these objections will probably be removed. High-pressure equipment light enough to use on pleasure cars may be developed. As knowledge of handling becomes more widespread and equipment is improved, the hazards involved will diminish. Fire hazard is a greater problem with the gases than with gasoline. More filling stations will come into being when demand for these fuels increases. The lower calorific value of gases per volume is compensated for partially by their better combustion and the higher compression ratios at which they can be used in specially designed engines. Since crankcase oil is not diluted and carbonaceous deposits are practically eliminated under proper operating conditions, the cost of lubricating oil and repairs is cut down. Good refrigeration may be obtained with liquefied gases, and trucks which carry perishable cargo often burn the same fuel in the engine that has been used to cool the refrigerator compartment.

A selected list of references is included in the bibliography.

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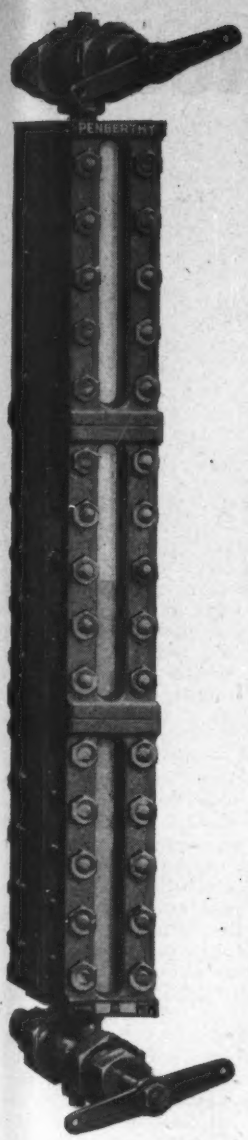


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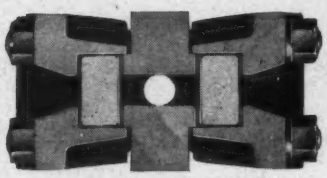

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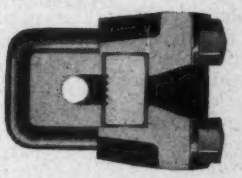

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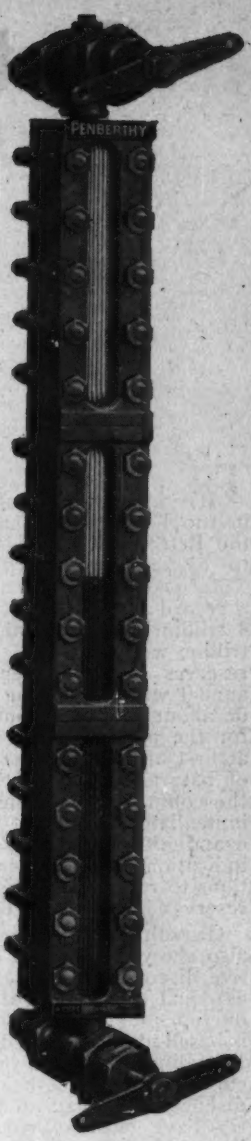


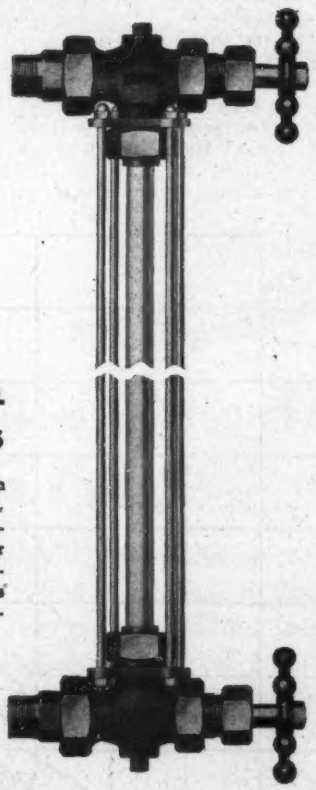

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# Future Gas Supply Twice Known Reserves

LYON F. TERRY
Second Vice President, The Chase National Bank, New York, New York

Before Natural Gas Spring Conference, American Gas Association,
French Lick Springs, Indiana, May 12, 1944

THE known reserves of natural gas in the United States are estimated by the Petroleum Administration for War to aggregate 110 trillion cubic feet. Total production of natural gas reached a record high in 1943 of approximately 4 trillion cubic feet of which some 3.3 trillion were marketed. Thus our known reserves are equivalent to 27.5 times annual withdrawals on a wartime basis or about 33 times annual requirements for the prewar period. While it would at first appear that the available supply of natural gas, from the standpoint of the country as a whole, is adequate for immediate purposes, we should also examine the rate of discovery and other indications of the probable future additions to reserves. The growth of known reserves is shown in Table 1.

Growth of discoveries and reserves is also shown in Figure 1 where cumulative discoveries at any date are plotted as equal to the sum of cumulative production plus proved reserves. The chart is based upon marketed production only. Including gas lost in operations, not accounted for on the chart, the total past discoveries of natural gas in this country have been approximately 200 trillion cubic feet.

The quantities of new gas reserves discovered and developed, by periods, since 1925, are indicated in Table 2. For comparative purposes, increases in reserves are based upon the Davis estimates.

While figures for additions to reserves should be considered as only relative, being based upon rough estimates of national reserves at successive intervals, the following trends may be observed:

(a) For the period 1926-34, which included the development of the Panhandle field and the discovery of Kettleman Hills and Hugoton, the rate of discovery and development of new gas reserves averaged 6.82 trillion cubic feet per year, or approximately 2¾ times the rate of withdrawals.

(b) During the 1935-43 period, including the discovery and development of important deep gas reservoirs in the Gulf Coast and Rio Vista in California, additions to reserves averaged 6.28 trillion cubic feet per year, or approximately twice the rate of production.

Thus for a number of years new gas reserves have been discovered and developed in quantities considerably greater than withdrawals from the fields, which has resulted in the building up of a substantial backlog of available reserves.

As we drill deeper in the search for oil and gas, the effect of the compressibility of gas becomes of special significance. Reservoir pressures are, of course, normally proportional to depth and while at great depths both the deviation from Boyle's law and the effect of higher temperatures tend to reduce the direct effect of pressures, the net result is all in favor of the existence of larger reserves of gas at greater depths. Other things being equal, an acre-foot of pore space filled with dry gas encountered at a depth of 10,000 feet should contain roughly 1¾ times the quantity of gas in a similar reservoir at 4000 feet.

In oil fields, the ratio of gas in solution to the oil found in place varies with depth and pressure in a relationship somewhat similar to that stated above for dry gas. Hence deeper drilling may be expected to reveal increasing proportions of solution gas per barrel of new oil reserves discovered in the future. And the continued improvement in methods of conserving gas in oil field operations should also add to the supply of natural gas available from this source.

Reported studies of changes in the nature of oil and gas with depth of the reservoir rocks offer no suggestion that gas will be less abundant or that the ratio of gas to oil will decrease with deeper drilling. The variation in the characteristics of oil with increasing

**TABLE 1**
**Growth of Natural Gas Reserves and Production in the United States**

| YEAR | (Trillion Cubic Feet) Est. Proved Reserves Jan. 1 | Total[a] Production For Year | Ratio of Reserves to Production |
|---|---|---|---|
| 1926 | 23[b] | 1.88[k] | 12.2 |
| 1931 | 46[c] | 2.58[k] | 17.8 |
| 1935 | 62[d] | 2.40 | 25.8 |
| 1938 | 66[d] | 2.95 | 22.4 |
| 1939 | 70[c] | 3.15 | 22.2 |
| 1941 | 85[d] | 3.44 | 24.7 |
| 1943 | 85[f] | 4.00[p] | 21.2 |
| 1943 | 110[g] | 4.00[p] | 27.5 |
| 1944 | 90[h] | ... | .... |
| 1944 | 110[g] | ... | .... |

[a] Gas marketed plus gas lost and wasted as reported by USBM. [b] Private estimate. [c] By Earle P. Hindes. [d] By Ralph E. Davis. [e] By Lyon F. Terry. [f] By Ralph E. Davis, as of 10-1-42. [g] By PAW including solution gas and gas cap gas reserves. [h] By Ralph E. Davis. Mr. Davis' estimates do not, in general, include solution gas primarily available for oil field operations. [k] Marketed production per USBM plus our estimate of losses and waste. [p] Preliminary estimate.

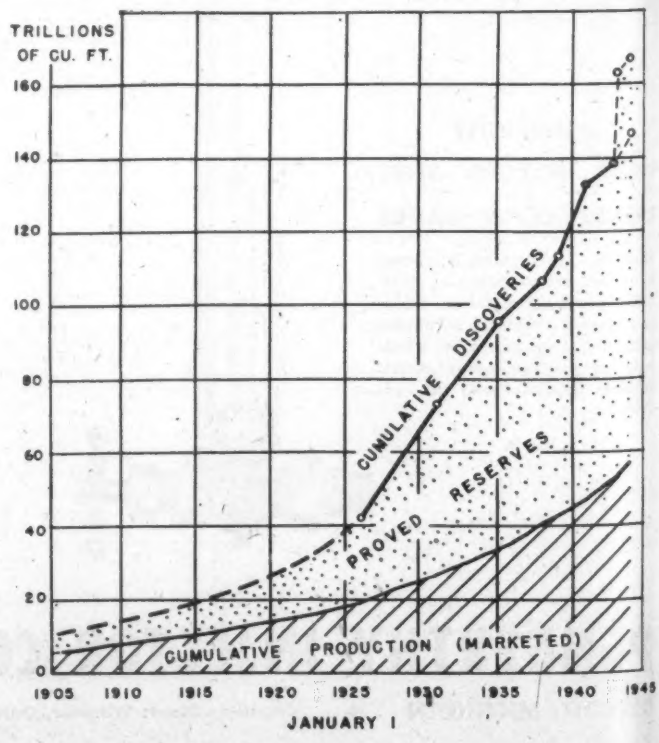


**FIGURE 1**
**Growth of natural gas discoveries and reserves in the United States.**

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**TABLE 2**

**New Gas Reserves Discovered and Developed Compared with Production**

| Periods | No. of Years | (Trillion Cubic Feet) Increase in Proved Reserves | Total Gas Production | New Reserves Discovered and Developed | | Ratio of New Reserves To Prod. |
|---|---|---|---|---|---|---|
| | | | | Total | Per Year | |
| 1926-30 | 5 | 23.00 | 12.91 | 35.91 | 7.18 | 2.78 |
| 1931-34 | 4 | 16.00 | 9.51 | 25.51 | 6.38 | 2.68 |
| 1935-38 | 4 | 8.00 | 10.84 | 18.84 | 4.71 | 1.74 |
| 1939-43 | 5 | 20.00 | 17.64 | 37.64 | 7.53 | 2.13 |
| 1926-34 | 9 | 39.00 | 22.42 | 61.42 | 6.82 | 2.74 |
| 1935-43 | 9 | 28.00 | 28.48 | 56.48 | 6.28 | 1.98 |
| 1926-43 | 18 | 67.00 | 50.90 | 117.90 | 6.55 | 2.32 |

depth and geologic age has been investigated for the Gulf Coast area to a depth of 7000 feet by Barton.[1] In general he found:

*"(a) increase in the percentage content of the lower boiling (lighter) fractions and decrease in the percentage content of the higher boiling (heavier) fractions with increasing depth and age; (b) increase of the API (Beaume) gravity (decrease of the specific gravity) of all fractions of the crude oil with increasing depth and age; . . ."*

While he stated no definite conclusions as to natural gas itself, his findings may justify the expectation that exploration at greater depths will reveal increasing proportions of condensate and of solution gas, compared with crude oil.[2]

There is evidence also that with deeper exploration the proportion of natural gas to crude oil discovered has been increasing. A notable increase in the discovery and development of condensate fields has occurred in recent years, particularly in the deeper developments of the Gulf Coast. This is well indicated by the results of exploration in the Gulf coastal area where the number of gas and condensate discoveries out of total successful wildcat completions increased from 7 percent in 1933 and 24 percent in 1934 to 52 percent for 1943, as shown in Table 3.

## Past Production and Discoveries

Natural gas produced and delivered to consumers from 1906 to the close of 1943, as reported by the Bureau of Mines, amounted to 51.4 trillion cubic feet. Marketed production for the Appalachian fields prior to 1906 has been estimated by Roth[3] at 4.8 trillion cubic feet. Together with smaller quantities produced in Indiana, Kansas, and elsewhere prior to 1906, we have a fairly accurate estimate of total marketed production in the United States to January 1, 1944, of 57 trillion cubic feet.

Since 1935 the Bureau has also reported losses and waste, stated as: "gas (mostly residue gas) blown to the air, and transportation losses, but does not include direct waste on producing properties, except where data are available." During recent years such reported losses have averaged 20 percent of total reported production exclusive of gas stored in the ground and used for repressuring. Prior to the enforcement of effective gas conservation laws by the principal gas producing states beginning in 1935 (California in 1931), the unconserved gas incident to natural gas and natural gasoline operations had been considerably higher. Including estimates of specific losses in the Panhandle, Oklahoma City, and California fields, it is believed that such losses have amounted to at least 20 trillion cubic feet.

There were also great quantities of gas blown to the air in the oil fields of this country before the establishment of conservation measures. The volume of such gas production will never be known. However some idea of its magnitude may be formed by considering the solution and gas cap gas that has been released with the 28 billion barrels of oil produced in this country to date, with due allowance for the portion of such gas utilized by the natural gas industry especially since the advent of casinghead gasoline practice some 30 years ago. The unconserved gas incident to oil field operations has been largely remedied in recent years by state conservation acts and proration of production, and through application of pressure maintenance and recycling processes. Thus the loss of gas such as occurred at Spindletop, Glenn Pool, Cushing Pool, and Burbank will not be duplicated in future oil fields; and insofar as past production may provide an index to the quantity of future discoveries, excessive volumes of unconserved gas formerly produced in oil fields, which would have been conserved under present and future practice should be included in figures of total gas production.

Summarizing, it is believed that the total effective quantity of natural gas produced to January 1, 1944 in the United States has been at least 90 trillion cubic feet. Adding the known reserves of 110 trillion, as estimated by the Petroleum Administration for War indicates total discoveries to January 1, 1944 of approximately 200 trillion cubic feet.

## Future Discoveries

The most important part of our natural gas resources are those undiscovered reserves that undoubtedly will be revealed by future exploration for both oil and gas. Future discoveries of natural gas, of course, cannot be estimated. Predictions that have been made at various times as to future production of oil and of gas in the United States have in all cases proven to have been much too low. For example, in 1919 it was predicted that the future recoverable and marketable reserves in discovered and undiscovered pools might reach a maximum of 15 trillion cubic feet.[4] Since that time 44 trillion feet have been produced and marketed.

While there is no way of foreseeing with any accuracy what future exploration may reveal, the problem may be approached thus. Extensive studies have been made by qualified geologists, of the proportion of marine sedimentary lands already tested to the prospective areas still available for further exploration, and of the finding experience for the portions of such lands found productive to date. Investigations indicate that of the total acreage in this country which may be expected to be ultimately productive, about one half has been proven for oil to the present time. As described by Pratt[5] and others the results of these studies point to the probability that additional reserves of oil will be found in this country in quantities at least equal to total past discoveries.

In general, the discovery of gas has run parallel to that of oil, and naturally so, since these hydrocarbons originate from the same sources and are found in similar and coincident reservoirs and sedimentary rocks. Considering also, in the case of gas, the effects of compressibility of gas under reservoir pressures found at increasing depths, the significance of the variation in the character of oil to be revealed by deeper drilling, and the recent trend toward discovery of an increasing proportion of gas fields compared with oil fields, there appears to be all the more reason to conclude that natural gas reserves to be discovered in the future will at least equal, and may exceed, the 200 trillion cubic feet discovered to date.

**TABLE 3**

**Trend of Exploratory Drilling in South Arkansas, Louisiana and Texas Gulf Coast (After PAW)**

| YEAR | Successful Exploratory Completions in Percent of Total Number | | | |
|---|---|---|---|---|
| | Oil | Gas | Condensate | Total |
| 1933 | 93 | 7 | 0 | 100 |
| 1934 | 76 | 13 | 11 | 100 |
| 1935 | 80 | 10 | 10 | 100 |
| 1936 | 72 | 16 | 12 | 100 |
| 1937 | 74 | 5 | 21 | 100 |
| 1938 | 66 | 7 | 27 | 100 |
| 1939 | 63 | 12 | 25 | 100 |
| 1940 | 66 | 9 | 25 | 100 |
| 1941 | 61 | 14 | 25 | 100 |
| 1942 | 56 | 14 | 30 | 100 |
| 1943 | 48 | 16 | 36 | 100 |

## Future Supply

Thus on the basis of our assumption that future discoveries of natural gas will at least be equal to total discoveries to date, the total potential resources of natural gas in the United States may be stated in round numbers as composed of known reserves in excess of 100 trillion cubic feet and assumed future discoveries of at least 200 trillion, or a total of 300 trillion cubic feet or more.

**Acknowledgment**

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[1] Donald C. Barton, "Evolution of Gulf Coast Crude Oil," A.A.P.G. (1937), Vol. 21, pp. 914-46.

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[4] Eugene W. Shaw, "Income and Expense of Natural Gas Production", Proc., Nat. Gas. Assn. of Amer., Vol. 11, (1919), pp. 479-503.

[5] Wallace E. Pratt, Vice Pres., Standard Oil Co. (N.J.), in recently published statements, particularly an address before the Oil Heat Institute of America, New York, March 13, 1944.

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# The Meaning of Freedom

*The address of Dr. Willard H. Dow, president of the Dow Chemical Company, on receiving the Gold Medal Award of American Institute of Chemists in New York, May 13, 1944*

EVERYONE, everywhere is trying to look into the future. The world about us is being torn into shreds and we do not know how or by whom it may be reshaped. Countless millions are longing for what they call security and seem willing to pay any price for any package labeled security. The sands of man's belief in himself as a being created in the image of God are running out. Men and women are trying to escape today by dreaming of tomorrow. Tonight I shall not talk about postwar planning or postwar hoping. Instead, I am going to ask you to explore with me the simple elements on which we of America have founded our lives, to the end of discovering whether or not, in much of our planning, we have not overlooked that one element without which our plans will be futile. I am going to ask you to consider freedom and what it means. And I am also going to suggest to those who think in such terms that freedom also has a cash value. But let us think in terms of the dignity of man and not of messes of pottage.

Let us be high-brow in order to see if in being low-brow—call it practical—we are not in danger of missing the very thing that we are trying to get. To be concrete. How many of us are really willing to accept the challenge of individual responsibility and make our own futures?

How many of us, I wonder, are watching for a chance to break out of the lock step of thought in which we as a people are now marching and to do a little walking at our own gait? And how many of us are just watchfully waiting for the line to break of itself, or, better yet, to be broken by someone we elect or select for that purpose? In other words, how many of us have the burning passion to step out for freedom? And how many of us are beginning to think of freedom as something we would very much like to have given to us? There is a whale of a difference between the two approaches.

Freedom is not a condition of life. It is the absence of a condition of life. The moment we think of it as a condition, we recognize—no matter what we may say to the contrary—a superpower which can tell us not only what is and what is not freedom, but also just how and why we must like it. I am reminded of that marshal of Napoleon's who, entering a captured town, summoned the citizens to the marketplace. "My friends," he declared, "I bring you the perfect freedom. But be prudent. I shall shoot the first man who stirs."

Take the slogan "free enterprise." Everyone seems to have gone overboard for free enterprise. But it appears that the securing of free enterprise is a very complicated matter, and I should hate to be given the task of reducing some of the prescriptions I read to an algebraic formula. "Free enterprise," if it is to be anything but a name, is not a permitted way of business. It arises out of an absence of a permitted way of business.

We seem to be forgetting that a government cannot grant freedom of religion or of speech or of enterprise. When we speak of granting or receiving freedom, we exactly reverse the processes of thought that moved those great men, the Founding Fathers, to evolve for themselves and their posterity—that is, for us—the Constitution and the Bill of Rights. We of America never wrung a Magna Carta from a king. Our forefathers fought and gained the right to think and act for themselves. The Declaration of Independence was a living, fighting thing and not just a nice resolution casually adopted at a convention. We did not derive our freedom from any government. On the contrary, we set up a government and lodged with it only such small parts of our freedom as we thought necessary for the preservation of a reasonable order. Our wise Fathers were so fearful that even these little trusteeships of freedom might be abused, that they delegated supreme power to no man and to no group of men, in the fervent hope that no government could ever be established as a thing of itself and apart from the people.

We today, without thought of our words, speak of the "Government" or of "Washington" as a ruling power, and there are many who would propitiate that power in much the way that the courtiers of old are said to have fawned on their monarchs. Our forefathers simply would not have known how to do that sort of thing. They did not depend upon a government. The government depended on them.

They derived their freedom to worship, to speak and to carry on from Almighty God and not from anything fashioned by man.

The utter reversal that has come about in our manner of thinking—a reversal which holds much evil and no good—is being driven in by a parade of authorities through committee rooms, through lecture halls and even through pulpits, solemnly warning us and exhorting us not to be hasty in getting rid of our wartime controls so as not to lapse into another dreadful era of tooth and claw. We are being warned against the dangers of freedom. We are being openly counseled to follow the cultures and even the diets of nations that never knew freedom. In the 'twenties, foreign missions were inspecting us to see how and why we managed so well. Now, in the 'forties, we are being taught that whatever we did in the past as a people was crude and quite wrong and that our future lies in being something other than American.

All of which, to me, is rot, for I do not happen to be one of those who believe that the United States is a failure. And, although we have a lot to learn and, if we keep our balance, we shall always have a lot to learn, I thing that what we have to learn from abroad is in the way of what not to do and not in the way of what to do. For if the cultures of Europe and Asia have brought them to their present pass, we have nothing to learn from them. So I am thinking and I would ask you to think about the moral basis on which this country is going to operate after the war. We hear a great deal about postwar planning, full production and full employment. These questions are all materialistic. But what about the individual? Where is he going to get off? Or has he vanished entirely?

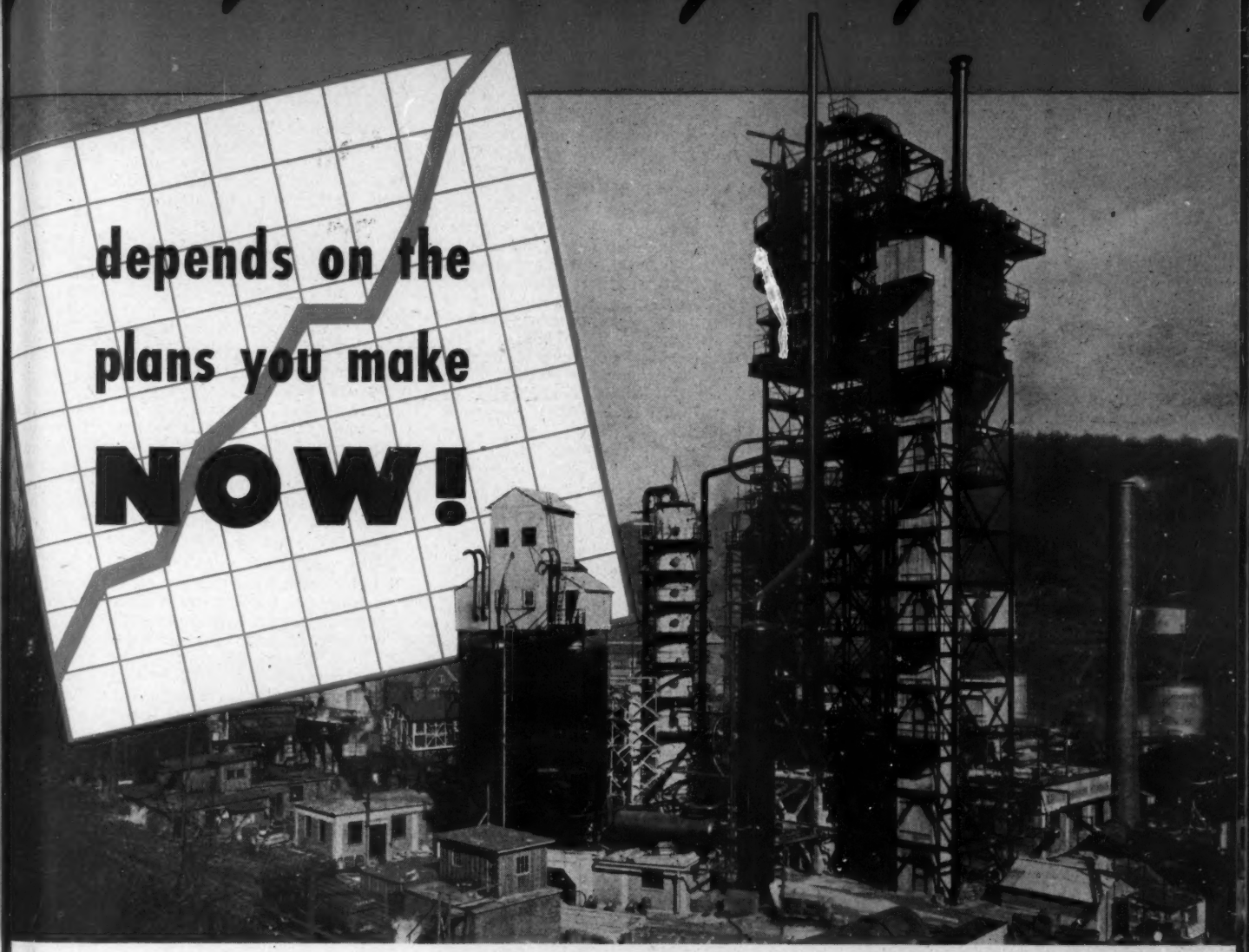
We are in an era of controlled economy. It is said, and for the purposes of this evening I will grant, that these controls are needed for the war. We are being told that controls are not in the American spirit, but that we must ease out of them and that chaos would follow their sudden ending. Some of those who advise us to go slowly have records of achievement in business and finance and therefore would seem to speak out of experience.

But by the very nature of our present controls we cannot ease out of them. We can only ease into permanent control and the kind of society in which the individual never has a chance to express himself. For one control breeds another. We have already seen how quickly price control leads to subsidy. And also we are witnessing how price control brings artificial gluts and shortages. Every housewife is becoming a ration-coupon speculator and in a measurable time we shall have to eat on a fixed quantity schedule. The next step must be forced labor, for in a controlled society it is out of the question for the individual to determine either the kind or the amount of labor he will contribute. Then we shall have exactly the same sort of freedom from want and from fear that the lifer enjoys in his cell.

For, although control is not a harsh word, economic control by its very nature must be harsh, because really it means the substituting of bureaucratic discretion and in the end the individual must be deprived of his responsibility and his dignity. We shall have to decide whether we want to be Americans and have government of our own choosing or be something else. There is no halfway point in human dignity and responsibility. It either is or is not.

The control mania—I cannot use a nicer word—has struck the sciences. Every few years a group of sincere and

# Your post-war prosperity




TO MEET postwar competition on a profitable basis your refinery will need revision or alteration. The McKee organization can help you make plans *now* to put your refinery in a balanced condition, so that all products will emerge at highest economic value.

Make sure that work on your postwar program starts on the earliest possible date by having design engineering completed *before* the war ends.

Arthur G. McKee & Company's comprehensive services, covering all phases of refinery design, engineering and construction are available to you. The war-broadened experience and ability of McKee process specialists, designers, engineers and other technical experts are at your disposal in planning your postwar program *now*.

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good men, as in a cycle, comes out with the recommendation that all advancement should be in the control of a single group of scientists.

The decisions recommended by them would govern our future development. Chemistry and physics offer possibly greater opportunity for the expression of new ideas than any of the other sciences. Each scientific brain has an approach or a way of looking at things that is entirely its own. Using this brain power can bring about greater results than could possibly be achieved by a wiser Solomon that has ever yet appeared.

Can you conceive what would happen if any group of scientists—no matter how able—were made the masters of research and discovery—if their composite experience were to make all the decisions? We discard the very thought as nonsense.

An idea, no matter how weird, may grow into a constructive thought and enlarge to a new approach. Then a new industry is aborning. Experience, ideas, research—all accumulate and produce a new approach or a new product or a new thought. Each borning is cherished by the one seeing the vision and is often communicated to others, but these visions are things coming only to those who have prepared themselves to accept them.

My own experience in research is such that I would dread the day when the bright spark of the young man who is searching the infinite might find himself in a thought prison with a keeper—no matter how well-intentioned and sympathetic that keeper might be. You all know that the best known and ablest of our authorities turned down the making of the cyclotron as useless. My company is making bromine from sea water, but, before finally getting under way, it was conclusively demonstrated, not only once but three times, that it could not be done. And lest I seem to be taking on airs, I will tell you that some years ago I maturely decided that, although the future of magnesium was unlimited, it would always be a specialty metal. But even at our present prices it is by volume among the cheapest of metals. We have learned that if a research laboratory is to produce results, the men must be allowed the freedom to be a bit crazy. If we were to control closely, we would miss the great idea that is found only by those with the courage to be crazy.

Chemistry and physics stand out nobly in the modern world of science. They are ever ready to give much and to accept little in return—which is the reverse of the modern world where the tendency is to receive all and give little. We are now in a terrible war—a war of complete destruction or maybe even elimination. Have we, as scientists, failed in our effort to humanity and permitted the operation of forces to work against instead of for civilization? Have we listened to the wrong teachers, to pedagogues of a wrong theology? Have we not been inspired by wrong thinking and gotten our quanta of energy confused with the molecules? Have we forgotten the only being worth remembering—the individual human being?

This is briefly what we have done. We have permitted the fostering of ideas our intelligence says are wrong. By pretending a knowledge we do not have, we have duped ourselves into false security. There is only one security and that grows out of the individual thinking for himself and that honestly and sincerely. This we know. But we are discarding all of our experience, traditions of past prosperity and our entire knowledge of success with individualism. We are, in short, discarding Americanism and all it stands for. That means we are discarding our moral basis.

There is much loose talk these days about after-the-war planning. In typical propaganda style, industry is held up as having the sole responsibility for taking care of all employment after the war is over. I, for one, do not believe this is possible and think it is just another scheme to dodge responsibility. For industry is always a servant and never a master. The responsibility is yours and mine. We must all make our contribution and resolve that there shall not be unemployment after the war. But we shall need to define what we mean by "employment" and by "unemployment." Everyone can be employed. But everyone cannot be employed at exactly the kind of job under exactly the conditions of wages and hours that he or she may want. And "full employment" comes perilously near to "directed" employment. There is no "right to work" but there is a responsibility to work. We need to do some hard thinking about rights and responsibilities, for there cannot be a right without responsibility nor a responsibility without a right. And that gets us right back to the individual.

In writing the Declaration of Independence and the Constitution, the fathers of our country were moved by the unalterable purpose to free themselves and their posterity from the oppression of the Old World and elevate the individual to sovereign dignity. They believed that thus they were fulfilling the Will of God. They builded with imperishable stone.

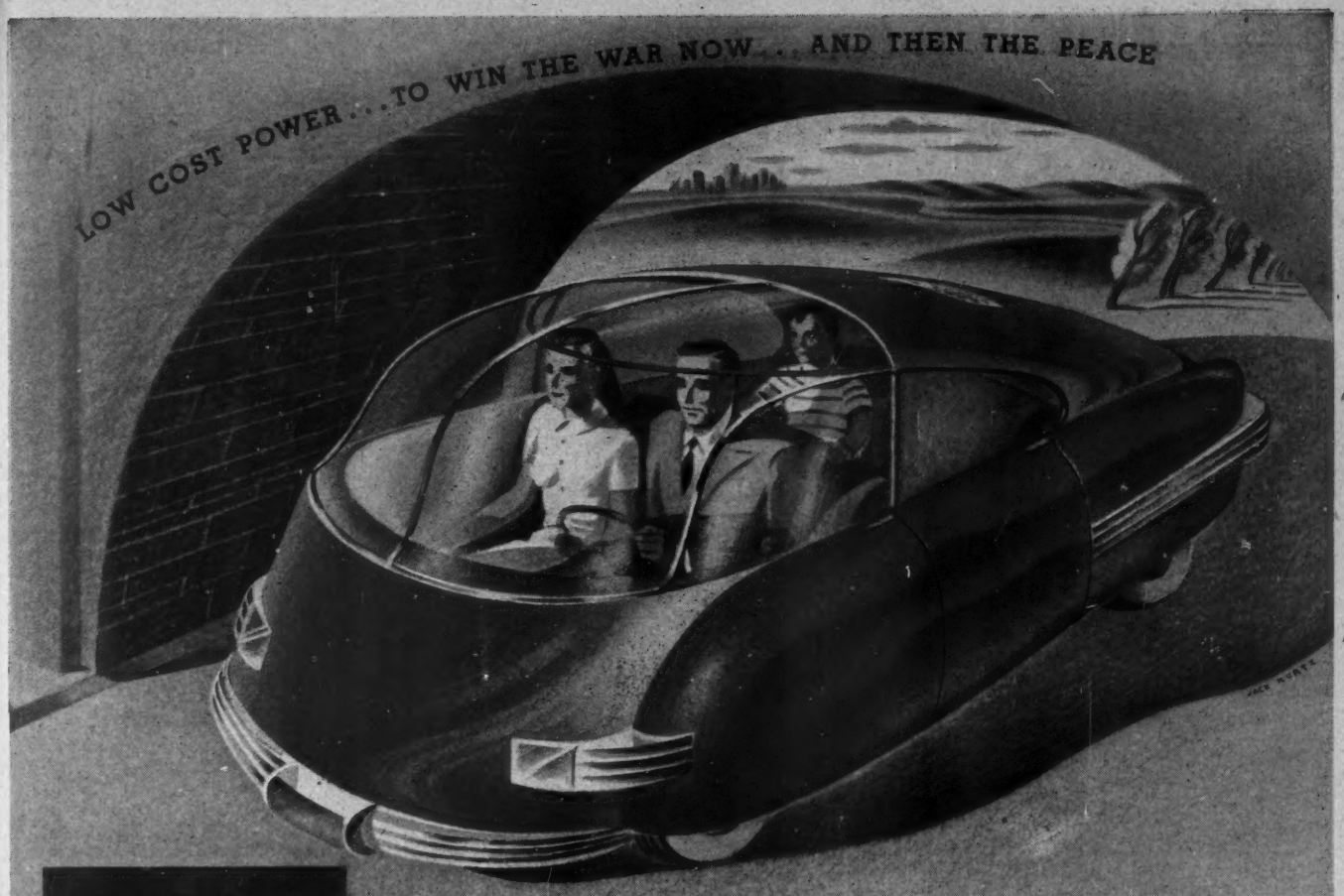
The elemental situation has not changed from their day to ours. Instead of a country of a few million people, we have a country of one hundred and thirty million people. That means more and not less opportunity. The world around us is much greater than theirs because, where their frontiers were limited by the map, our frontiers are unmapped, for they are far off somewhere in the great new world of physical discovery. Nothing has happened to make necessary a change in our concept of individualism.

The upheaval which has come about in our manner of thinking is, I feel, due to two causes. One is the influence upon our basic thinking by European systems of thought generated by failure, and the other is our neglect to cherish and foster the great freedom—the freedom of the ordinary, everyday American.

It is not easy for a nation to keep its freedom, and history teaches us that many have failed. But there never was a freedom born like the American. Our job is to prepare and to guard that freedom so that the way to greater accomplishments may be opened. Our successes are small in contrast to that which will eventually be accomplished. Our efforts are good and bad building stones of the future. There is always much room out in front—room for all without crowding—and work for generations to come. Let us now dedicate ourselves to avoiding the stumbling blocks and the unnecessary delays on this road of progress.

We must once again take up the belief that the only Divine Power is within man himself—he is the creation of God. If the American system has failed, it is because we, as individuals, have failed. In man alone can we find hope for a future. Whatever may be the seeming dangers of throwing off our controls and once more being Americans, they are as nothing in contrast to the dangers of being merely a tended herd. It all depends on whether we have what it takes. I think we have.

**Workers at Standard Oil Company of Louisiana, Baton Rouge, shared a birthday cake to commemorate the first anniversary of the butadiene plant at that refinery.**



# Paging the Jeep's Nephew

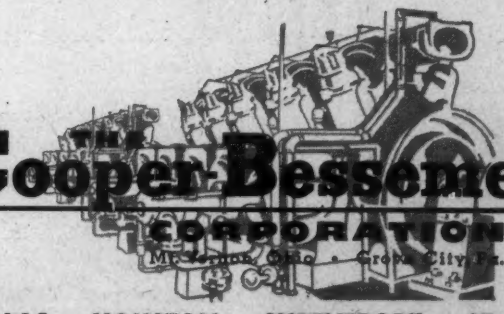
THE jeep owes a lot to Cooper-Bessemer compressors. It bounds along on synthetic rubber which starts in a compressor. Compressors aid in refining its fuel. It is equipped with compressor-born plastic parts and accessories.

And to the compressor, the tear-drop car of the future —the jeep's nephew—will owe even more. It may have a small but powerful motor hidden under the rear seat, made of magnesium and aluminum alloys, fueled with high-octane gasoline. Tires of synthetic rubber will roll up new-record mileages. Cushions of synthetic foam-rubber will bring the luxurious riding ease of the airplane. Fixtures, accessories, surface finish will be of jewel-like plastics.

Magnesium, plastics, synthetic rubber, high-octane gasoline . . . all are products of compression.

Compressors by Cooper-Bessemer are making these products in steadily increasing volume to meet modern warfare's crucial need . . . a need no less vital to the modern peacetime "American Way."

Wartime or peacetime, Cooper-Bessemer concentrates on building long-lived, reliable Diesels, gas engines and compressors. Thus, constantly improved Cooper-Bessemer equipment is always available to meet the demand for greater efficiency and lower-cost horsepower.



**The Cooper-Bessemer CORPORATION**

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# Steam, Alcohol Injection Enter Automobile Fuel Picture

Two recent news reports in reliable general publications, "Business Week," and "The Wall Street Journal," are worthy of consideration within the petroleum industry. Each offers some evidence that developments in power plants are such that this industry may be looking in the wrong direction when it turns so much attention to the possibility of insufficient crude oil. One report concerns the development of a steam engine, adaptable to both the airplane and the automobile; the other gives some details on injection of a water-alcohol combination in a gasoline engine.

Commercial status of the two developments may not come for a decade. But they are something more than mere calculation. The steam engine, as reported in the May 20 issue of "Business Week" is the invention of a Chicago engineer, Louis C. Trosky, who has 800 hours of flying in airplanes powered by steam engines.

The summary of the report is that the new steam engine will operate on fuel oil, condense all steam, operate on a head of 600 pounds, have only 6 percent as many working parts as the gasoline motor and, "The fuel oil it burns contains about 3000 more Btus than 100-octane gasoline, pound for pound. Result is that the Laboratory thermal efficiency of Trosky's engine is said to be 56 percent, compared with 28.3 percent for gasoline aviation engines now made."

The design provides for the engine to get required oxygen for high-level flying by liberating it from hydrogen in steam. Crew and passengers can be provided with oxygen from this source.

This development has possibilities for the automobile:

"Trosky has developed steam engines for automobiles, one of which with 150 horsepower is said to have had extraordinary pickup of 100 miles per hour within a city block, from a standing start. Another inventor, Abner Dobel, is working along similar lines in developing a steam engine for use in automotive equipment. A large bus company is reported to be considerably interested in his work, which is now shrouded in secrecy."

The Wall Street Journal of May 18 carried a lengthy news report of the success of injecting 100-proof whiskey, 50 percent water and 50 percent alcohol into the fuel steam of an airplane with this result that low-grade gasoline performed as well as high-octane gasoline. Part of the report from this publication gives this pertinent information of especial interest to the petroleum industry:

"The development incorporates the work of a number of engineers rather than any one individual and several prominent heavy trucking and aircraft engine manufacturers are interested in postwar possibilities. . . .

"One specific test of a truck engine, for instance, indicates that if this particular model were operated 40,000 miles a year, the savings through use of a cheaper, lower octane gasoline would total about $250. Because the alcohol serves as a solvent for the binder on carbon deposits, it acts in engines as a carbon remover; this, it is estimated, would save about $77 a year in carbon removal and repairs. Balanced against this estimated savings of $327 a year would be the need for about 100 gallons of alcohol, plus water, and a pinch of an ingredient used to render the mixture unpalatable to the thirsty. This mixture would probably cost about $60 now, but after the war might be had for $50, or possibly even less. Thus the net savings to this particular truck operator were indicated at $277 a year.

"Another test case indicates that a passenger automobile owner who covers about the average 10,000 miles a year would save approximately $50.

"The injection device itself, consisting of two small jets fitting into the carburetor, plus a supplementary fuel tank and connections, is moderate in cost and could be amortized in a few months of operation through fuel-cost savings.

"More than 400 of these devices are now operating on trucks and passenger autos. The first ones were installed, on an experimental basis, as early as 1939."

## Sinclair Starts Plant At Corpus Christi

Sinclair Refining Company's six-case Houdry fixed-bed catalytic cracking plant at Corpus Christi, Texas, began operating early in May. It has a daily capacity of 11,000 barrels and is charging gasoil from Southwest Texas crude. Facilities have been installed for blending finished aviation fuel.

Designed originally for Terminal Refining Corporation which undertook to build it as a Defense Plant Corporation project, Sinclair Refining Company acquired the property in 1942, investing its own capital in building and operation. It is the thirty-fourth catalytic cracking unit using the Houdry process for aviation base stock, and is the twenty-fourth fixed-bed unit in operation.

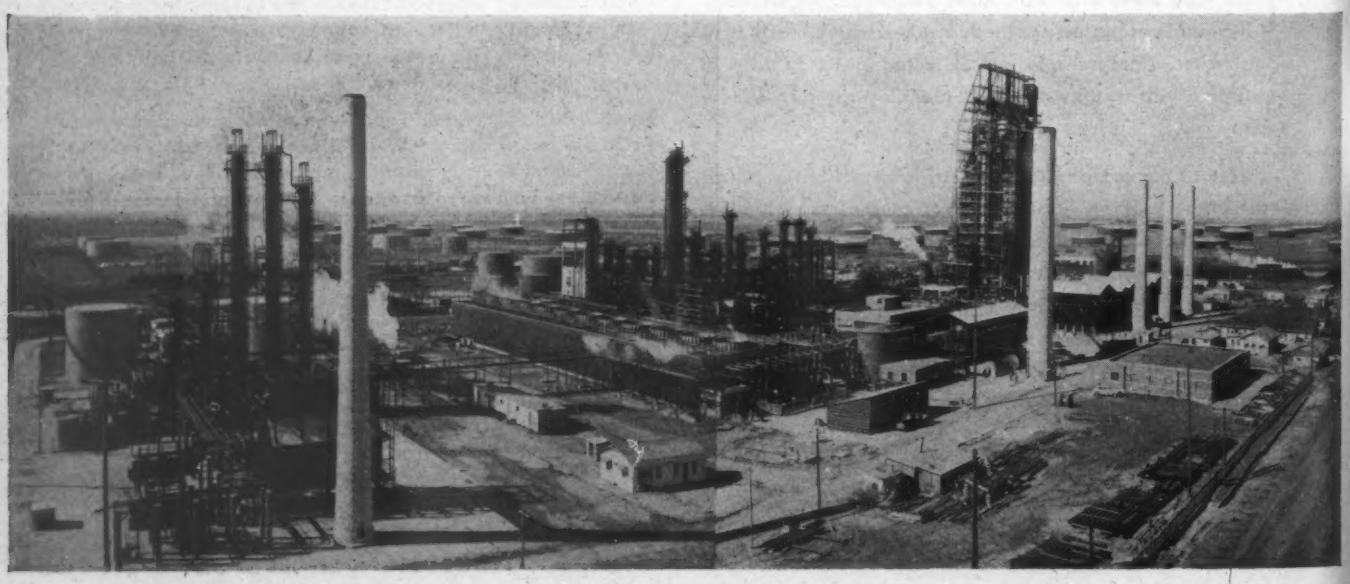
## Refinery in Venezuela Is Planned by Sinclair

Deliveries of oil in Venezuela to Sinclair Oil Corporation are running in excess of a million barrels monthly, H. F. Sinclair told stockholders at the annual meeting. The company has drilled more than 70 wells there, has three dry holes and is running seven strings of tools. Sinclair reported the company is increasing its pipe-line capacity in Venezuela from 40,000 to 75,000 barrels daily and said that "we hope to build a refinery in Venezuela in the near future."

## Continental Completes Aviation Gasoline Plant

All units of the 100-octane-aviation-gasoline plant of Continental Oil Company, Ponca City, were put in operation for the making of the first barrel of this grade of motor fuel in one plant in Oklahoma, May 25, 1944.

"Although Continental Oil Company as well as other Oklahoma refiners have been making ingredients for 100-



Continental Oil Company's aviation gasoline plant recently completed at Ponca City, Oklahoma.

# ..HERE WE

# 73,040 H.P.

## OF CLARK "ANGLES" TO CALIFORNIA IN 4 YEARS . . . HALF OF IT IN 1943

**CLARK Compressors have had wide acceptance in California, due to their fine record there for continuous operation.**

**When the demand for compressors for Hi-Octane Gasoline developed, CLARK delivered the goods. Not a single shipment has been late.**

**Today, with the advent of deeper fields and lighter crudes, California operators are producing large volumes of gas and are in position to make use of the advantages that accrue from pressure maintenance. CLARK deliveries to California in the past 4 years, principally for refinery and pressure maintenance service, have totalled 73,040 Horsepower. Half of that total was shipped in 1943.**

7 CLARK 1000 H. P. gas-driven "Angles" in refrigeration service in a California refinery

12 CLARK 7500 H. P. gas-driven "Angles" in service in California's Synthetic Rubber Industry

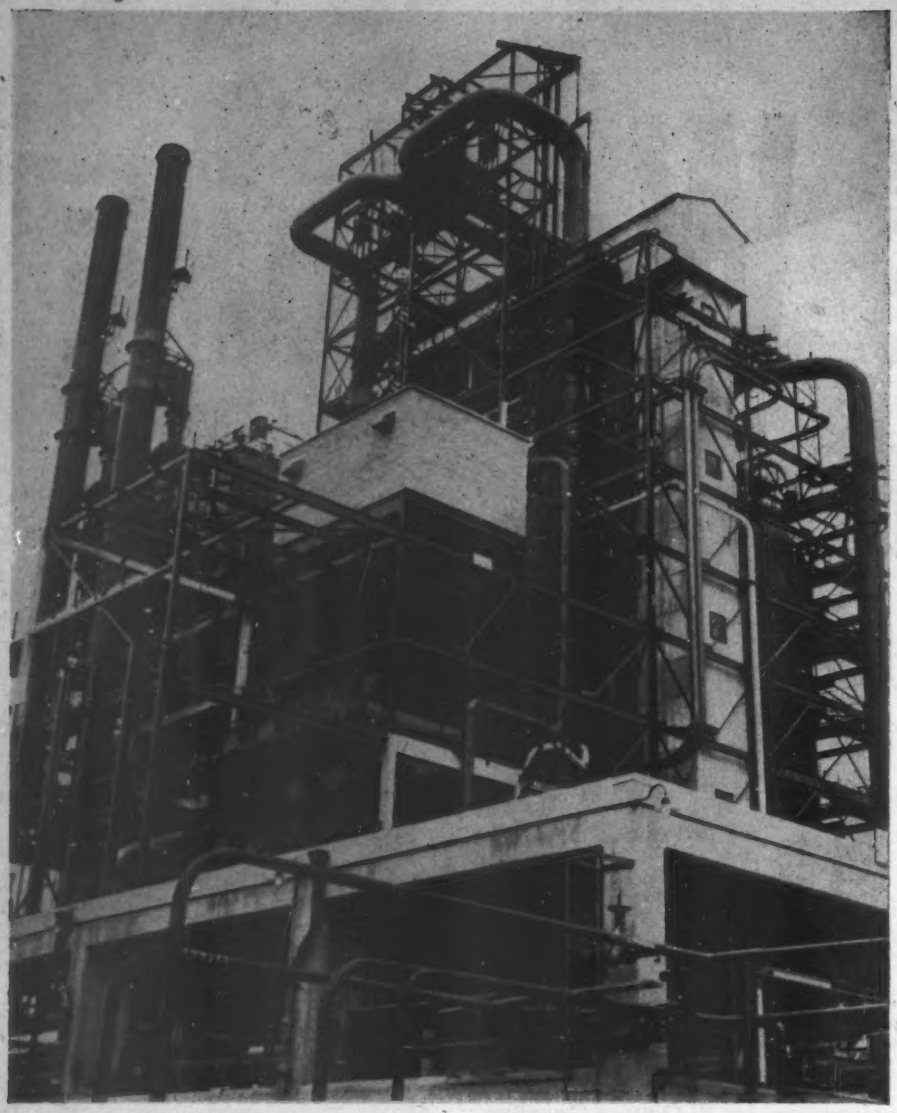
2 CLARK 3000 H. P. steam-driven "Angles" in California refinery making Hi-Octane Gasoline

One of The Dresser Industries


**CLARK BROS. CO., INC.**
**OLEAN, NEW YORK, U. S. A.**

**Export Offices: 30 Rockefeller Plaza, New York. Domestic Sales Offices and Warehouses: Tulsa, Okla.; Houston, Tex.; Chicago, Ill. (122 S. Michigan Ave.); Boston, Mass. (Park Square Bldg.); Huntington Park, Calif. (5715 Bicket St.) Foreign Offices: London, England; Avda Roque Saenz Pena, 832, Buenos Aires.**


# CLARK Sets the Compress



One of three catalytic cracking units in the plant of Cities Service Refining Corporation at Lake Charles, Louisiana.

octane-aviation gasoline for several years," explained Walter Miller, vice president, "this new plant is the first in the state to manufacture the finished product."

Facilities added to the Ponca City plant for making this high-octane product include a twin Thermofor catalytic unit, a TCC retreating unit, an hydrofluoric-acid alkylation unit and an isomerization unit, using the aluminum-chloride process. These facilities are self contained, having a control laboratory, individual rail facilities and storage separate from the remainder of the plant, as well as separate water-cooling facilities and steam plant.

Raw feed to the Thermofor unit comes from the existing facilities of the Ponca City plant.

## George L. Stewart Heads Imperial Refineries

G. Harrison Smith, president of Imperial Oil Limited, has been made chairman of the board, and has been succeeded by R. V. LeSueur, who has been vice president and a director of the company since 1933. LeSueur joined International Petroleum Company (subsidiary of Imperial Oil) in 1926 and was active in that company's operations in South America, becoming a vice president of that company the same year he was added to the official staff of the parent company, and also the same year Smith was made president of Imperial Oil Limited.

George L. Stewart, general manager of Imperial Oil Limited's refineries, has been named vice president in charge of manufacturing, succeeding L. C. McCloskey, who has retired after 41 years service with the company.

## Williams Joins Western Refiners as Technologist

Paul D. Williams has joined Western Petroleum Refiners Association as technologist and will have headquarters at Tulsa. He has been connected with several refining companies in Oklahoma and Kansas, and before his present connection was chief chemist for Oklahoma Corporation Commission.

## Herron to Bahrein

A. J. Herron, former assistant superintendent of The Texas Company's refinery at Dallas, has been transferred to Bahrein Island where he will be assistant superintendent of the refinery.

## Cities Service Plant At Lake Charles Dedicated

Cities Service Refining Corporation and Firestone Tire and Rubber Company dedicated their integrated aviation fuel, butadiene and synthetic rubber plants at Lake Charles, Louisiana, May 26.

Deputy Petroleum Administrator Ralph K. Davies made the principal address. Other speakers included W. Alton Jones, president of Cities Service Company, and Harvey S. Firestone, Jr., president of Firestone Tire and Rubber Company.

The refinery incorporates fluid cracking, sulphuric-acid alkylation, butane isomerization and propane de-asphalting units.

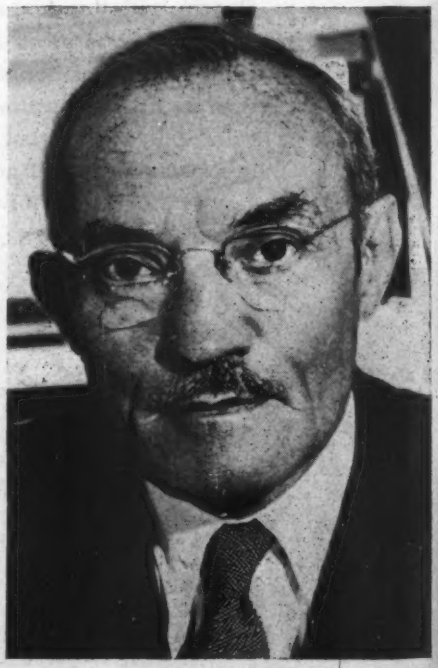
Designed, engineered and constructed by The M. W. Kellogg Company, the plant is one of the war's outstanding industrial projects, and is the largest single refinery installation project ever undertaken under one company responsibility.

This is the first completely new refinery of major size built in 20 years. Starting from scratch, the designer constructors were able to utilize all the newest facilities coordinated in a centralized plan, achieving maximum efficiency and production. This unity of design gives the plant a big increase in gasoline yield from crude.

The project embraces 18 major structures including 3 of the world's largest fluid catalytic cracking units, and units for topping, desalting, butane, isomerization, treating, alkylation and many others, all fitting into a single pattern with a power plant which services the entire refinery.

## Egloff Again Heads Institute of Chemists

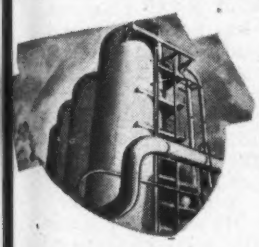
Dr. Gustav Egloff, director of research for Universal Oil Products Company, Chicago, was reelected president of the American Institute of Chemists at the annual meeting in New York, May 13. Other officials are: Dr. Donald Price, vice president; Dr.



DR. GUSTAV EGLOFF

GENERAL CHEMICAL

## AGAIN GENERAL CHEMICAL CREATES NEW FACILITIES FOR SULFURIC ACID TO SERVE AMERICAN INDUSTRY

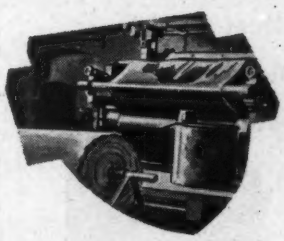


**Petroleum**
Alkylation, sulfonation, and improving color, odor, and stability of petroleum products.

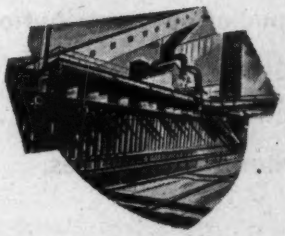
**Rayon**
Used in the spinning bath in rayon manufacture.

**Steel**
For pickling of steel sheets and castings; removes oxides and scales.

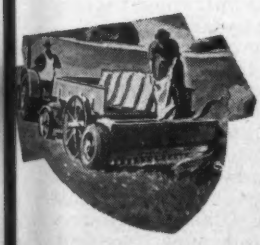
**Paints**
Raw material in production of pigments; for sulfonating drying oils.



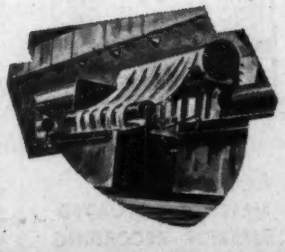
**Sulfonation**
Sulfonating vegetable oils for water, fire, and mildew-proofing fabrics and textiles.



**Coke By-Products**
For washing toluene and benzene, raw materials for dyestuffs and explosives.



**Fertilizers**
Used in super phosphate and ammonium sulfate production.



**Textiles**
For carbonizing wools and for the dyeing bath in production of textiles.

**GRADES OR STRENGTHS**
Standard: From 60° Baume to 65% Oleum (114.6% $H_2SO_4$)
Special High Purity:
Diamond—66° Baume, Carboys Only
Crystal —66° Baume, 98% $H_2SO_4$
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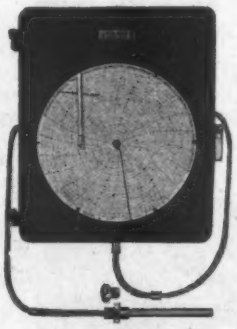

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Councilors at large were chosen as follows: Donald H. Andrews; F. G. Breyer, Stuart R. Brinkley; Harry L. Fisher; Donald B. Keyes, Raymond E. Kirk, Frank Ol Lundstrom, Robert J. Moore, Foster D. Snell and W. D. Turner.

A symposium preceded the election, at which Doctor Egloff reported on the past year and announced plans for next year.

Dr. Harry S. Rogers, president of the Polytechnic Institute of Brooklyn, spoke on "Attributes of a Profession."

Dr. Harvey N. Davis, chairman of the office of production research and development of the War Production Board, and president of Stevens Institute, spoke on "Victory Through Technology."

"Defining the Chemist" was the subject of Dr. M. L. Crossley, director of research of the American Cyanamid Company.

Dr. Raymond E. Kirk, head of the department of chemistry, Polytechnic Institute of Brooklyn, and past chairman of the New York Chapter of the American Institute of Chemists, discussed "Employer-Employe Relations."

## Shell Makes Promotions In Refining Personnel

Horace S. Dale, who has been superintendent of the Wood River plant of Shell Oil Company, has been appointed manager of the manufacturing department with headquarters in New York. Other changes are: Frank C. Cutting becomes superintendent at Wood River; Stanley J. Meisenburg has been promoted to assistant superintendent of gas plants at that plant; Albert B. Culbertson, manager of the products application department, has been granted leave to serve as chief of the aviation section, Division of Refining, PAW; Peter E. Keegan has been promoted to assistant manager of the personnel department in the head office; Mahlon S. Hale has been named manager of the industrial relations department at the Houston refinery.

Dale has been superintendent at Wood River since January 1, 1941. He came to the organization as gauger at Wood River in 1924 after attending school at the University of Pittsburgh. He remained at Wood River until 1933 when he went to Arkansas City as acting superintendent but returned to Wood River as a special technologist later that year. He became assistant superintendent in charge of operating, topping and cracking the next year.

Cutting, who is now superintendent at Wood River, became a gas engineer in Tulsa in 1925, following graduation from the University of Michigan. Three years later he was transferred to Wood River as technical assistant. From 1930 to 1939 he was in the Houston plant and the St. Louis office and at the East Chicago plant as assistant superintendent, technologist and superintendent. He returned to Wood River as assistant superintendent of lubricating units in 1939 and a year later was promoted to assistant superintendent of the gas department.

Meisenburg came to Wood River as a research chemist in 1939 after graduation from the University of Michigan. He had been technologist at Arkansas City and at the St. Louis office before going to New York in 1940 as senior

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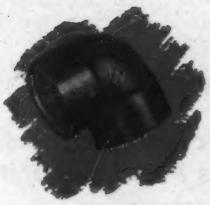

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technologist. He was in charge of the design section of the development division previous to returning to Wood River.

### Davies Expresses Regret Over Miller Resignation

Resignation of Max B. Miller as director of the construction division and appointment of George Gibson, formerly assistant director, as his successor was announced May 30 by PAW.

"It is with keen regret and a great deal of appreciation for Mr. Miller's outstanding work in PAW that I accept his resignation," Deputy Administrator Davies said in announcing the change.

"For more than two years he has carried the principal load of the 100-octane refinery construction program, probably the most critical of all the war programs under PAW."

Gibson, the new director of the construction division, was chief process engineer for C. H. Leach Company, New York, from 1929 to 1940, when he became a refinery technologist and consultant of Hancock Oil Company, Long Beach, California. He was drafted by PAW in September, 1941.

### McCoy Succeeds Jergins As PAW Security Head

Allen A. Jergins, director of the faculty security division of PAW at Washington, resigned May 1 to return to his duties as vice president of Jergins Oil Company at Long Beach, California, from which he has been on leave since August, 1942.

William K. McCoy has been appointed to succeed Jergins. He has been with PAW since September, 1942, coming from Gulf Oil Corporation's engineering and construction division at Pittsburgh.

### Refinery Gets Elaborate Personnel Building

Preliminary work has been started for the construction of a new medical and personnel building for Standard Oil Company of Louisiana at Baton Rouge. The facilities will be completed as conditions permit. The new building has been designed for the main entrance to the plant on the highway near Istrouma. The main building will be a combination one- and two-story structure, 250 by 70 feet. The police and customs building will be 65 by 20 feet and the clock and sales building 90 by 33 feet.

In the upstairs portion of the personnel and medical building will be housed the offices of W. P. Reymond, Jr., the personnel manager, and his assistants, also the offices of the safety and training departments, which are in charge of A. J. Ferguson and T. S. Keaty, respectively. On the same floor a large assembly hall, several conference and training rooms, plus offices for the department assistants and clerical personnel will be included.

On the ground floor, at the front of the building, will be the employment and annuities and benefits departments, while at the rear the timekeepers and the identification and rationing personnel will be placed. W. W. Weldon, assistant personnel manager, heads up the employment group, B. H. Farrier the annuities and benefits group, B. F. Ander-

**At some unpredictable tick of the clock this welcome command will ring throughout the world.**

**FIRST will be wild exultation, then prayerful thanksgiving and finally realistic appraisal of the spiritual as well as the economic condition of a battled scarred world.**

**After the celebration has run its course, we must go back to work for there will be so much to do. The "Arsenal of Democracy" will gradually fade into "civies" and the "Storehouse of Democracy" will take over.**

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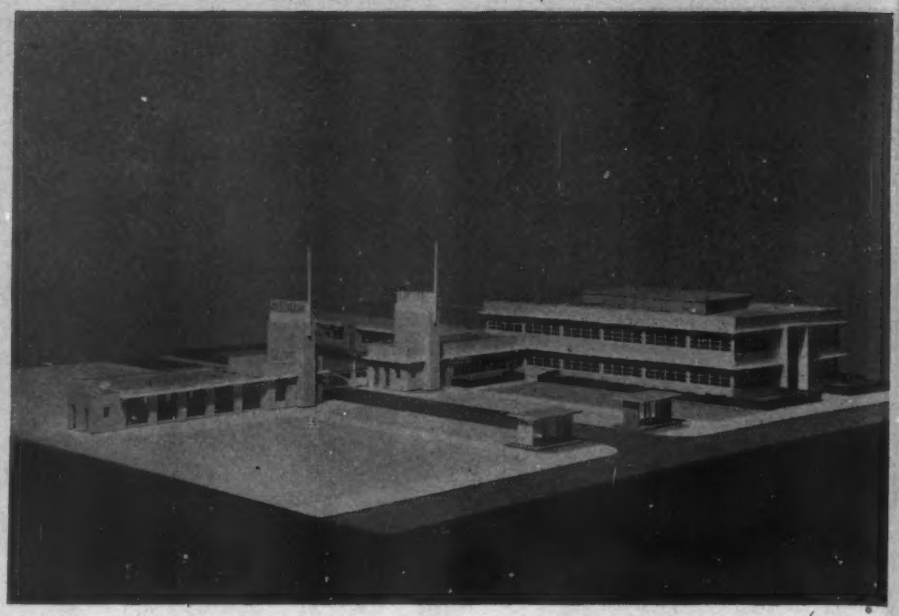

Baton Rouge personnel building.

son the identification and rationing group, and S. V. Arbour the timekeeping and recording group.

The employment department will occupy the greater portion of the ground floor part of the personnel building.

The medical department of which Dr. C. E. Allen is director, will occupy the one-story portion of the personnel and medical building. In this section will be housed several doctors' offices and consultation rooms, ward and treatment rooms, X-ray and physiotherapy rooms, laboratory and clerical offices, waiting rooms and so forth. The ambulance entrance to the plant hospital will be on the south side of the buildings, within the refinery gate.

### *Legislation Would Stop Alien Property Return*

Legislation providing that enemy-owned oil and other patents and properties seized by the Alien Property Custodian following our entry into the war shall not be returned to their former owners has been introduced in Congress by Senator Pat McCarran of Nevada.

The bill is designed to make effective a policy enunciated by President Roosevelt that we should not repeat the mistake made following the last war, when alien properties and patents were returned to their former owners.

The measure provides that not only may the physical properties not be reclaimed by their former enemy owners but that they shall not receive any of the proceeds from the sale or other disposition by the Alien Property Custodian.

### *Hiram J. Halle Died May 29*

Hiram J. Halle, president of Universal Oil Products Company, died May 29 at Pound Ridge, New York. He was born in Cleveland, Ohio 77 years ago. He entered petroleum refining at the time the automobile was coming into mass production, and for more than 25 years was an outstanding figure in the growth and development of the refining industry.

He became president of Universal Oil Products Company in 1915, at the request of J. Ogden Armour, its principal stockholder, after having successfully managed and sold Armour's Standard Asphalt & Rubber Company, of which he was president. Under Halle's leadership, the Universal organization moved to the front in invention, development and servicing of processes which have revolutionized the refining industry, starting with the Dubbs cracking process and progressing through continuous research and development work to the perfecting of a number of catalytic refining processes, which today are playing a major role in the production of 100-octane gasoline, toluene for TNT, and the components of synthetic rubber.

Halle presided at the first public demonstration of the Dubbs process at Independence, Kansas, in the summer of 1919. It was a milestone in refining history. The demonstration was completely successful and the process was speedily accepted by refiners the world over.

HIRAM J. HALLE

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# DIGEST OF UNITED STATES PATENTS

## Patents on Desulfurization, Issued in 1943

Compiled by Heinz Heinemann

**U.S.P. 2,309,652. Removal of Mercaptans from Mercaptan-Solvent Mixtures.** L. W. Leum and E. R. Birkheimer to The Atlantic Refining Company.

In order to regenerate alcohol used in the desulfurization of hydrocarbons, a vaporized mercaptan-alcohol mixture is passed in intimate countercurrent contact with an aqueous alkali solution under such conditions that the vaporized alcohol may be continuously and completely separated from the solution while the mercaptan content of the alcohol is converted into alkali mercaptides which are soluble in the solution and which may be removed therewith. The alkali solution can then be treated to decompose the mercaptides and regenerate the alkali. Temperatures must be sufficiently elevated to prevent condensation of the alcohol vapors.

**U.S.P. 2,309,871. Treatment of Hydrocarbon Fluids.** W. A. Schulze and G. H. Short to Phillips Petroleum Company.

When hydrocarbons containing carbonyl sulfide are brought into contact with solid absorbent reagents impregnated with primary amines a reaction takes place to convert the carbonyl sulfide into a compound insoluble in the hydrocarbon stream and retained by the treating agent. A contact time of 12 minutes to 2 hours is employed. The amount of amine present varies between 1 and 20 percent by weight of the reagent.

**U.S.P. 2,311,328. Refining Light Hydrocarbon Distillates.** P. V. Brower and L. Love to Shell Development Company.

The action of doctor-sweetening solution is improved by carrying out a doctor-treating process under conditions such that there is an alkyl phenol content in the alkaline plumbite solution which is maintained at a concentration of 8 to 15 grams per liter and preferably at 9 to 12 grams per liter.

**U.S.P. 2,311,342. Sulphur Removal from Hydrocarbons.** W. J. Kerns and C. M. Beamer to Standard Oil Development Company.

Carbonyl sulfide is removed from gaseous mixtures and from solutions containing same by reaction with monoethanolamine and formation of diethanol urea. The monoethanolamine can be applied in an aqueous solution comprising from 15 to 60 percent monoethanolamine. By heating the mixture after reaction to 200 to 220° F., diethanol urea is precipitated. It can also be precipitated by removal of water from or addition of an alcohol to the solution. Operating conditions of the process are 60 to 120° F. and a pressure of from 5 to 6 atmospheres.

**U.S.P. 2,311,562. Refining of Mineral Oils.** H. J. Moyer to Standard Oil Development Company.

Sulfur compounds from hydrocarbon vapors produced in catalytic cracking operations are removed by contacting the hydrocarbon vapors with a relatively-high-boiling liquid hydrocarbon having a gravity from about —5° A.P.I. to about 10° A.P.I. at a temperature in the range from about 600 to 850° F.

**U.S.P. 2,311,593. Method of Treating Hydrocarbons.** V. A. Kalichevsky, E. T. Scafe and K. F. Haden to Socony Vacuum Oil Company.

Free sulfur, hydrogen sulfide or mercaptans can be removed from oil by contact with anhydrous alkali particles. The time of reaction and the quantity of alkali required for sweetening gasoline depend primarily on the surface of the alkali exposed to the gasoline. By reducing the particle size to colloidal dimensions (with a diameter of 0.00001 to 0.0000001 cm.) satisfactory conditions can be obtained. Such colloidal solutions can be prepared in colloidal mills, in the electric arc by spraying molten anhydrous alkali into gasoline, etc.

**U.S.P. 2,312,365. Utilization of Foul Steam for Hydrogen Sulfide Removal.** W. H. Shiffler and S. P. Elliott to Standard Oil Company of California.

A process is described which comprises mixing hydrocarbons containing mercaptans with an aqeous alkali solution, regenerating said aqueous alkali solution in order to remove said mercaptans from said hydrocarbons, separating the said hydrocarbons thus freed of mercaptans from said aqueous alkali solution for further use in mercaptan absorption by steaming the same, passing the foul steam, containing mercaptans, to a hydrogen-sulfide-removal treatment wherein hydrocarbons containing hydrogen sulfide are passed through an alkaline liquid absorption medium for hydrogen sulfide, after which the hydrogen-sulfide-free hydrocarbons are separated from the absorption medium and the absorption medium is regenerated for re-use and employing foul, mercaptan containing steam from the mercaptan removal system to regenerate said hydrogen sulfide absorption medium.

**U.S.P. 2,312,820. Method for Removing Mercaptans from Petroleum Oil.** L. M. Henderson, and G. W. Ayers to The Pure Oil Company.

To remove weakly acidic organic sulfur compounds from otherwise substantially neutral hydrocarbon fluids, the fluids are contacted with an aqueous alkaline solution containing a hydrolyzable salt of an unsubstituted organic acid, having at least one carboxyl group attached to aliphatic carbon but having one or more alkyl hydrogens replaced by halogen. The alkali metal hydroxide solution is dilute. Sodium chloroacetate has been found to be a particularly effective salt. Temperatures upward of 90° F. are recommended.

**U.S.P. 2,314,217. Treatment of Hydrocarbon Gases.** H. Y. Hyde, C. K. Villand and L. S Galstaun to Tide Water Associated Oil Company.

Light hydrocarbon gases containing predominantly $C_3$ and $C_4$ hydrocarbons and containing hydrogen sulfide and mercaptans are purified by fractionating the $C_3$ hydrocarbons and hydrogen sulfide from the $C_4$ hydrocarbons and mercaptans treating each fraction with an alkali agent and blending the treated fractions.

**U.S.P. 2,315,144.** Treatment of Hydrocarbons. K. M. Watson to Universal Oil Products Company.

Sulfur compounds are removed from hydrocarbon oils by first dehydrogenating the oil with a dehydrogenation catalyst under dehydrogenation conditions. Pellets or granules of magnesium oxide composited with a chromate are suitable catalysts when applied at 750 to 1400° F. and pressures of 0 to 100 pounds. Olefins, aromatics and hydrogen are produced. The hydrocarbon fraction is then hydrogenated with the generated hydrogen at 750 to 1000° F. and 750 to 5000 pounds, converting the sulfur to hydrogen sulfide and effecting substantial saturation of the olefins.

**U.S.P. 2,315,480. Method for Reconditioning Used Solutizer Solutions.** L. E. Border to Shell Development Company.

A contaminated aqueous alkali metal hydroxide solution which was used to extra weak acids from a sour hydrocarbon distillate is regenerated by steam stripping. Resinous emulsifiers accumulate in the aqueous solution. The aqueous solution is then contacted with a water-treating sludge to entrain resinous emulsifiers and the sludge containing entrained emulsifiers is separated from said oil.

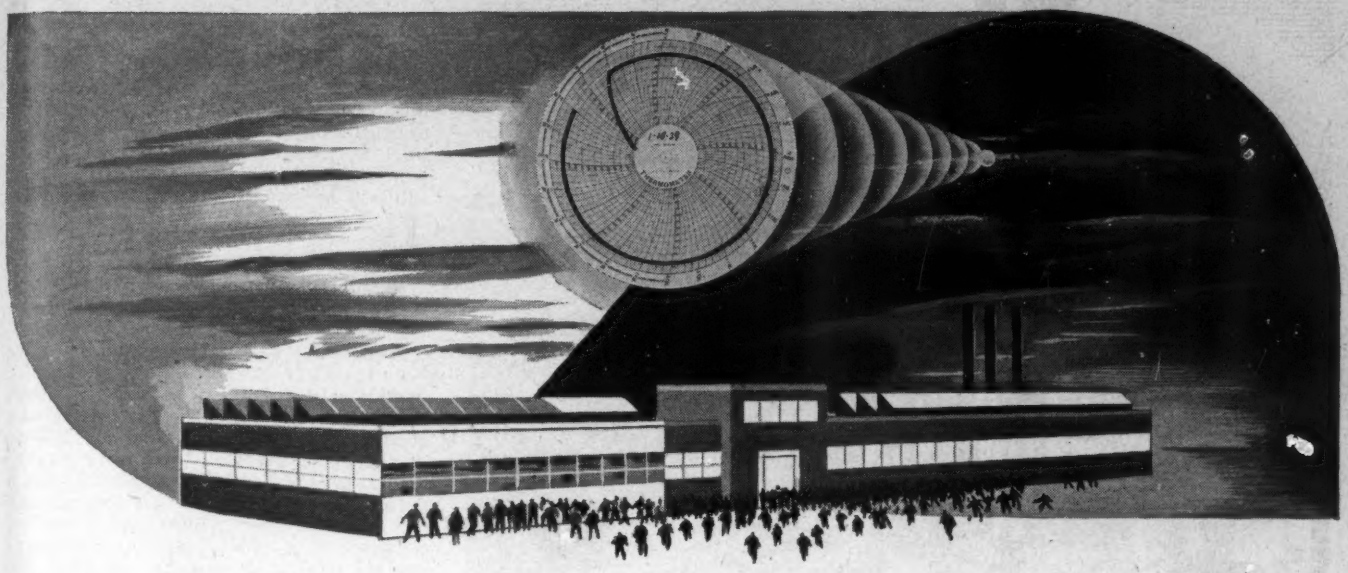
**U.S.P. 2,315,662 and U.S.P. 2,315,663. Treatment of Hydrocarbons.** W. A. Schulze, A. A. Ruoho and G. H. Short to Phillips Petroleum Company.

In order to remove carbonyl sulfide from hydrocarbon fluids essentially free of hydrogen sulfide and mercaptans, the fluid is contacted with a solid reagent comprising an adsorbtive carrier such as fuller's earth, other clay type minerals or synthetic aluminas, impregnated with an aqueous solution of a soluble cadmium salt to the extent of from 1 to 10 percent of the cadmium salt and treated with a caustic alkali solution having a PH between 8 and 14. The space velocity is 0.5 to 5 liquid volumes per volume of reagent per hour. The cadmium salt can be replaced by a cupric salt.

**U.S.P. 2,315,875. Process for Treating Hydrocarbons.** W. A. Schulze and L. C. Morris to Phillips Petroleum Company.

Anhydrous cupric chloride is used for

# This process operation couldn't afford a SHUTDOWN



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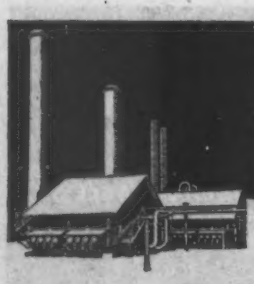

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Combustion Company

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Los Angeles • Houston • San Francisco

the removal of alkyl sulfides from hydrocarbons.

**U.S.P. 2,317,053. Alkali Treatment of Hydrocarbon Oils.** L. M. Henderson to The Pure Oil Company.

Untreated hydrocarbon oil, containing mercaptans is first contacted with an aqueous alkali solution and later with caustic methanol. The aqueous alkali solution removes mercaptans boiling lower than methanol, while the caustic methanol removes all other mercaptans. The methanol is recovered from spent solution by fractional distillation and is recycled.

**U.S.P. 2,317,054. Method of Treating Petroleum Oils.** L. M. Henderson and G. W. Ayers to The Pure Oil Company.

Aqueous alkali solutions which have been used to treat certain petroleum oils, particularly certain relatively low-boiling petroleum distillates, contain certain constituents which enhance the ability of the alkali solution to remove weakly acidic organic sulfur compounds from petroleum oils to such an extent that the oils can be rendered sweet to the doctor test by such treatment. According to this invention, mercaptans are removed from oils by treatment with aqueous alkali solutions containing naphthenic acids, phenols and thiophenols extracted from crude oil and freed from hydrolyzable constituents by steam stripping.

**U.S.P. 2,317,055. Method for Removing Organic Acidic Substances from Hydrocarbon Fluids.** L. M. Henderson and G. W. Ayers to The Pure Oil Company.

The ability of alkali solutions to remove acidic bodies from water immiscible liquids can be enhanced by adding thereto suitable quantities of rosin or colophony which contains 80 to 90 percent of abietic acid, its anhydride or isomers. A solventizer is required to enable sufficient quantities of the rosin to dissolve in the alkali solution. Phenolic compounds having more than six C-atoms per molecule and thiophenols give excellent results as solventizers.

**U.S.P. 2,317,600. Treating Hydrocarbon Distillate.** W. L. Benedict to Universal Oil Products Company.

Low-boiling petroleum distillates containing mercaptans are sweetened by a process in which a solution of an alkali metal carbonate is electrolyzed at 150 to 200° F. to form an alkali metal hydroxide and an alkali metal bicarbonate solution. The petroleum distillate is treated with the hydroxide solution at 50 to 100° F., the mercaptan containing alkali metal hydroxide solution is separated and commingled with the bicarbonate solution at 140 to 175° F. The mercaptans are liberated and alkali metal carbonate solution is returned to the electrolysis.

**U.S.P. 2,318,495. Treatment of Hydrocarbons.** W. W. Johnstone to Universal Oil Products Company.

The mercaptan content of hydrocarbon oils is reduced by treating the oils in the presence of solutions of alkali metal hydroxides containing nitro-paraffins. The nitro-paraffins increase the solubility of mercaptans in the alkali solutions. Satisfactory solutions are composed of 5 to 50 percent by weight of nitro-paraffin, 1 to 50 percent by

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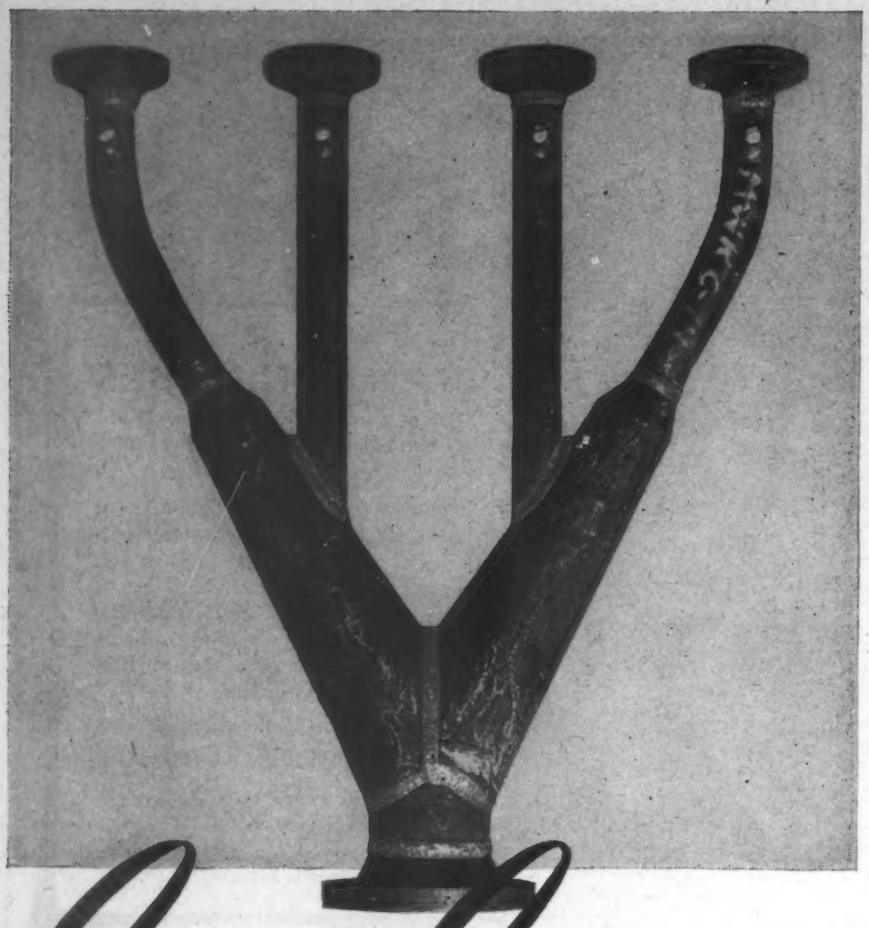
If a COPPUS "Horse Power" Steam Turbine can power your pump, blower, fan, stoker, dryer, mixer, etc. . . . then you'd waste money and metal buying an "Elephant Power" Turbine. COPPUS Blue Ribbon Turbines come in 6 frame sizes; matching size to job saves critical metal for war and money for yourself.

And the blue ribbon means workmanship that promises peak performance.



Strange Shape FOR A RIGHT ANSWER

Requirements in industrial piping, when converted into actual fabrication, often assume strange shapes. Odd pieces such as the carbon moly unit shown above (for use in 100 octane plant) usually require something better than average welding procedures. Associated qualifies for work of this character because certified welders using the most modern pre-heating, stress-relieving equipment are employed in our shops.... Whether your piping problems are simple or complex, Associated fabrication will be the right answer....

ASSOCIATED PIPING & ENGINEERING CO., Inc.
2332 East 38th Street • Los Angeles 11, California

weight of alkali metal hydroxide with the remainder made up of water. The treatment is carried out at atmospheric conditions.

**U.S.P. 2,319,354. Production of Motor Fuel of Low Sulfur Content.** C. C. Sperling to Petroleum Conversion Corporation.

A stream of heated hydrocarbon vapors is commingled with a high-temperature stream of heat-carrier gas and the mixture retained in a reaction chamber for the cracking of the vapors at a temperature of 975 to 1075° F. A substantially sulfur-free heat-carrier gas is supplied in a quantity that the gas:oil vapor ratio is of the order of 1:3 by weight. The complex sulfur compounds break down into removable sulfides, such as hydrogen sulfide to the substantial exclusion of sulfur compounds in the gasoline range. All of the vaporizable reaction products are intimately contacted with a sulfide removing agent.

**U.S.P. 2,320,047. Method of Desulphurizing Oils.** E. M. Nygaard and O. M. Reiff to Socony Vacuum Oil Company.

Sulfur is removed from gasoline by heating the gasoline under refluxing conditions with about 2 percent of its weight of wax substituted aluminum phenate for a period of about 3 hours and then distilling the gasoline from the reaction mixture.

**U.S.P. 2,320,277. Process of Sweetening Petroleum Distillates.** M. C. K. Jones and R. C. Brandon to Standard Oil Development Company.

In the doctor treatment of hydrocarbon oils, metal sulfides and particularly lead sulfide are often hard to separate from the oil and settle out in storage tanks later on. According to the invention the metal sulfides are separated from the oil with the aid of an aqueous dispersion of a small amount of a polysaccharide, such as starch, dextrim or the like. The distillate is washed with 5 to 30 percent by volume of water containing 0.05 to 1.0 percent by weight of a polysaccharide which is capable of being hydrolysed to glucose at a temperature of 30 to 120° F. and atmospheric to 30 pounds pressure.

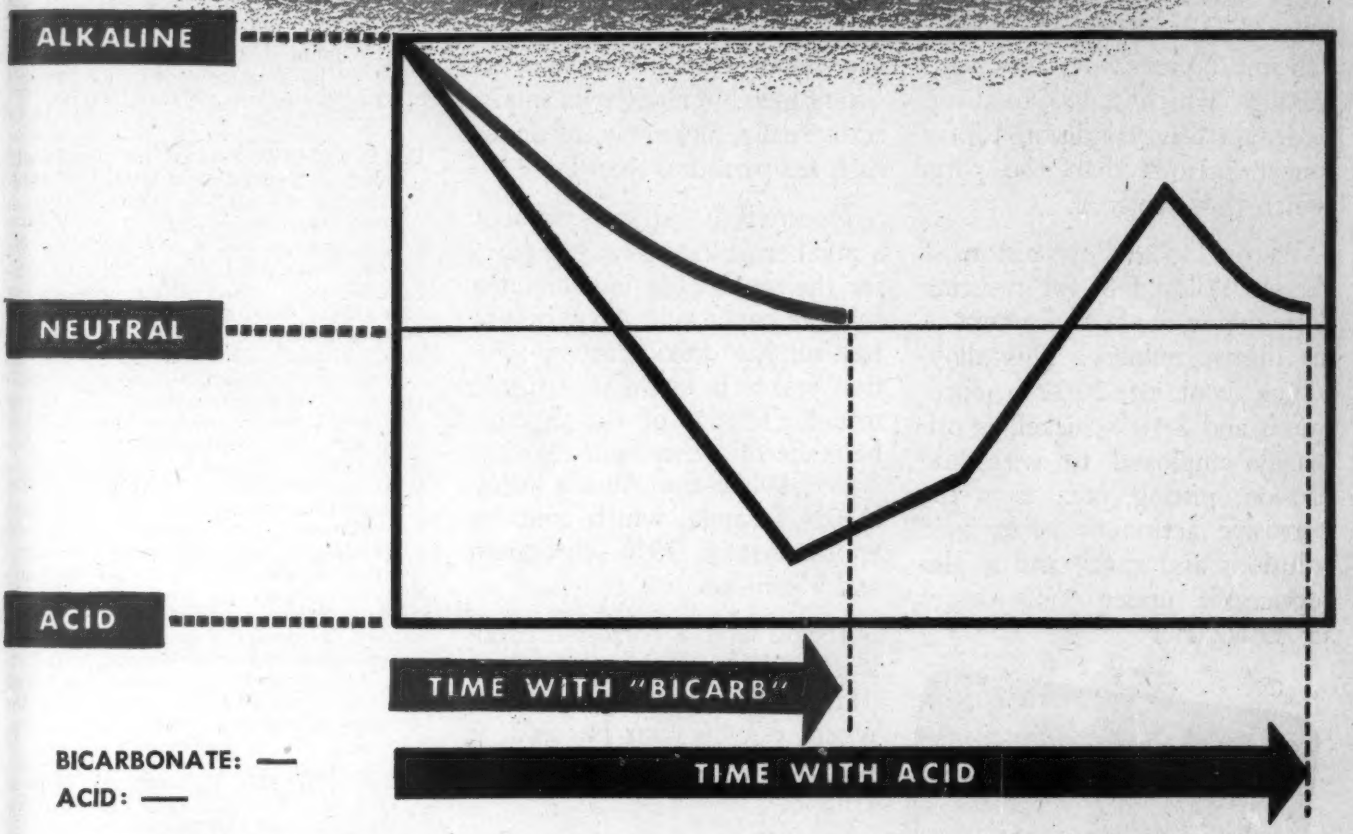
**U.S.P. 2,320,939. Removal of Mercaptans from Mercaptan-Solvent Mixtures.** L. W. Leum to The Atlantic Refining Company.

A process to remove mercaptans from mercaptan - alcohol mixtures produced during the regeneration of spent alcoholic alkali solutions resulting from the treatment of mercaptan containing hydrocarbon oils with alcoholic alkali solutions is described. The mercaptan-alcohol mixture is vaporized and the vapors passed into intimate contact with an easily reducible metal oxide, preferably copper oxide, at a temperature between about 150 and 350° F. at substantially atmospheric pressure. The mercaptans are converted to disulfides without substantial degradation of the alcohol and separated by fractionation. Formation of metal sulfides must be avoided.

**U.S.P. 2,324,066 and 2,324,067. Purification of Hydrocarbon Oils.** G. C. Connolly to Standard Oil Development Company.

Catalysts prepared by combining vanadium oxide with a hydrous oxide of

# USE "BICARB" TO REMOVE CAUSTIC!*




## A NEW MATHIESON DEVELOPMENT

Eliminating acid's disadvantages, bicarbonate of soda effectively removes caustic by changing it into sodium carbonate or soda ash.

Originated and commercially developed by Mathieson Research, this new process offers certain definite advantages:

- *acid resistant equipment not required.*
- *no health or other hazards involved.*
- *production speeded by elimination of additional steps necessitated by acid process.*
- *careful chemical control unnecessary.*

These advantages, plus new ones stemming from intensive research, may hold important meaning for you — may bring to light possibilities you haven't thought of.

While complete details for the utilization of this process have been evolved specifically for textiles, Mathieson Research is prepared to carry out further assignments in other fields.

For best results, consult our Technical Staff in regard to adapting this new Mathieson development to your particular operations. Write for further information.

**Mathieson**
**CHEMICALS**

*PATENT PENDING

THE MATHIESON ALKALI WORKS (INC.) 60 EAST 42nd STREET, NEW YORK 17, N. Y.

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# Under Corrosive Processes Amsco Alloy Stands Up . . .

Resistance to corrosion is imperative for many equipment parts if frequent replacements and high maintenance costs are to be avoided. Through use of the proper grade of Amsco Alloy we have been able to furnish "chemical process" plants with castings which have stood up under corrosive conditions for far longer periods than the parts which they replaced.

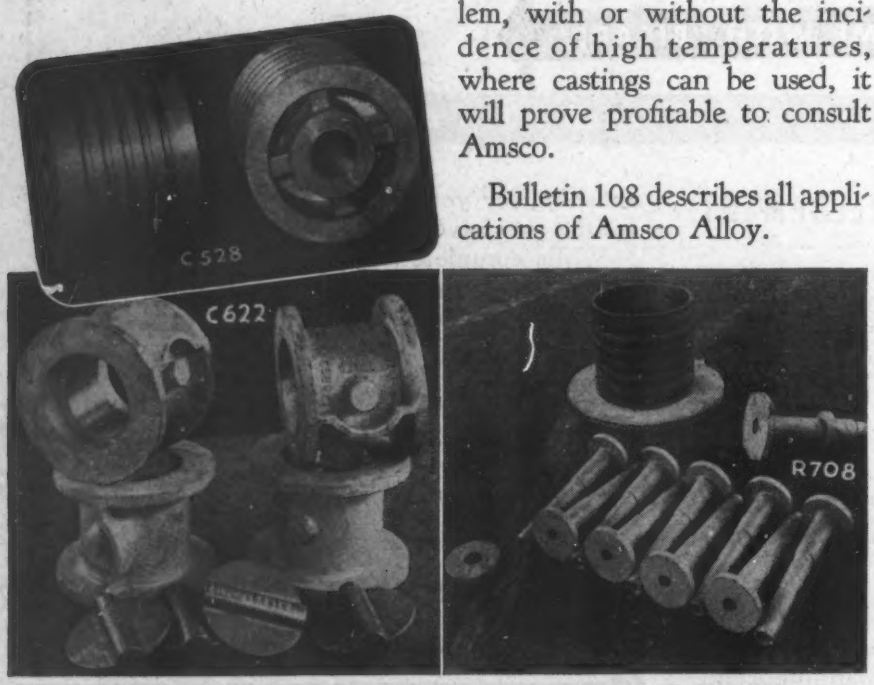
Picture C-528 shows pistons of Amsco Alloy F-8, for resisting corrosion in the hot oil pumps of an Illinois refinery. This alloy, which contains 20-22% chromium and 8-10% nickel, is primarily employed to withstand erosion, pitting, etc., from the corrosive action of acids, acid solutions and gases; and is also serviceable under temperatures up to 1600° F.

Picture C-622 shows some valves and valve bodies employed by an aluminum producer in handling corrosive liquids. These castings are of Amsco Alloy F-10, containing 26-28% chromium and 10-12% nickel, which is also an excellent corrosion resistant metal in many uses and is, additionally, more efficient under high temperatures than F-8.

Picture R-708 shows several of a number of Amsco Alloy parts for the wood pulp digester at a sulphite paper mill. An excess of free sulphur dioxide in the solution makes it essential that the metallic fittings of the digester be made of a corrosion resistant material, like the Amsco Alloy F-10N formula, which contains approximately 29% chromium and 9% nickel.

If you have a corrosion problem, with or without the incidence of high temperatures, where castings can be used, it will prove profitable to consult Amsco.

Bulletin 108 describes all applications of Amsco Alloy.




Advantages of Amsco-Nagle Centrifugal Pumps described in Bulletin 940.

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AMERICAN MANGANESE STEEL DIVISION
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FOUNDRIES AT CHICAGO HEIGHTS, ILL.; NEW CASTLE, DEL.; DENVER, COLO.; OAKLAND, CALIF.; LOS ANGELES, CALIF.; ST. LOUIS, MO.
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silica or a hydrous oxide of silica containing alumina form highly effective catalysts for the removal of sulfur impurities from hydrocarbon oils and gases. Large volumes of water must be imbibed within the structure of the oxide and not be chemically combined or in solution within the oxide. For most effective results the amount of vanadium oxide in the catalyst should be from 5 to 10 percent. After incorporating the vanadium oxide into the hydrous oxide, the product is dried at low temperatures and then activated at about 800" F. The catalysts have an apparent density between 0.50 and 0.70. The hydrocarbon oil is passed over the catalyst at a rate of 1 volume of liquid feed per volume of catalyst per hour at 800 to 900° F. Alumina used as carrier may be peptized by treatment with an organic acid, such as acetic or formic acid.

**U.S.P. 2,324,790. Process for the Sweetening of Hydrocarbon Oils.** J. H. McClintock to Standard Oil Development Company.

A continuous process for the sweetening of hydrocarbon oils containing mercaptans is described which consists essentially in continuously contacting the oil in a sweetening zone with a doctor solution under conditions to convert all mercaptans to disulfides and to precipitate lead sulfide, continuously separating the spent doctor solution containing most of the precipitated lead sulfide from the sweetened oil containing a small amount of flocculant precipitated lead sulfide, regenerating the spent doctor solution to convert lead sulfide into plumbite solution, continuously contacting the oil containing flocculant lead sulfide in a clarifying zone with the regenerated doctor solution free from lead sulfide, continuously separating clarified sweetened oil from the regenerated doctor solution and continuously recycling the regenerated doctor solution to the original sweetening zone.

**U.S.P. 2,324,927. Refining of Mineral Oils.** W. O. Heilman to Standard Oil Development Company.

For the removal of mercaptans from a gasoline, it is segregated in 60 to 80 percent of a relatively low-boiling and 40 to 20 percent of a relatively high-boiling fraction. The first is treated with 20 to 40 percent of an alkali metal hydroxide solution which is thereafter separated and treated with oxygen containing gas to convert mercaptides to disulfides. The high-boiling fraction is treated with 80 to 60 percent of the alkali metal hydroxide solution and separated. The treated fractions are combined as are the alkali metal hydroxide solutions which are treated with steam to remove the sulfur compounds and recycled.

**U.S.P. 2,324,948. Process of Refining Petroleum Oils.** H. C. Paulsen to Standard Oil Development Company.

Small amounts of copper contained in copper-sweetened oils and deleterious to the stability of the oils are removed by treating them with salts of arsenic acid, particularly basic metal salts of arsenious acid, termed arsenites. The arsenites may be prepared by neutralizing a solution of arsenious acid with a basic metal hydroxide; they have compositional formulae like $NaAsO_2$, $Na_3AsO_3$, $Na_4As_2O_5$, $Na_3As_4O_7$. The oil may be contacted with arsenite solutions

# KENNEDY
## BRONZE GLOBE VALVES

*All Standard Disc Types*

**Fig. 89**
**Bronze Globe Valve with Renewable Composition Disc**

**You will find that these valves operate easily . . . close tightly . . . give dependable, lasting service. Fig. 89 illustrated is typical of Kennedy Bronze Globe Valves . . . strong . . . designed to speed-up piping jobs . . . simplify operation . . . keep maintenance costs low. Available disc types include bronze, renewable composition, regrinding, full way, and plug type for steam pressures up to 300 lbs. For complete catalog, write**

**THE KENNEDY VALVE MFG. CO. • ELMIRA, N. Y.**

# N°1 INSULATING CEMENT

## . . . Gets Along Fine with Metal Surfaces

A special rust-inhibitor used in B-H No. 1 Cement prevents corrosion. Whether applied on a hot surface where it dries immediately or is allowed to air-dry over a long period of time, it will not attack metal surfaces. This means a permanent bond—an installation that stays put.

No. 1 Cement is sufficiently elastic to absorb ordinary expansion and contraction without peeling or cracking. Made of high-temperature-resisting, nodulated B-H *black* rockwool, long fibred asbestos, and colloidal clay, it does not form a homogeneous mass. The rockwool retains its physical characteristics and the countless number of dead-air cells provide maximum insulating efficiency up to 1800° F. Send for sample and complete data. *Baldwin-Hill Co., 567 Klagg Ave., Trenton 2, New Jersey. Plants in Trenton, New Jersey; Kalamazoo, Michigan; and Huntington, Indiana.*

**Baldwin-Hill**

**COMPANY**

**HEAT & COLD INSULATIONS**


or with carriers impregnated with the arsenite reagent.

**U.S.P. 2,325,033 and 2,325,034. Desulphurizing Catalyst.** A. C. Byrns to Union Oil Company of California.

A desulfurization catalyst is described which consists of up to 50 percent cabalt molybdate of the probable formula $CoO.MoO_3$ precipitated upon the previously undried synthetic hydrous metal oxide gel. The carrier class consists of aluminum, zirkonium, titanium and thorium oxide gels. The desulfurization is carried out at temperatures between 550 and 900° F. and pressures from atmospheric to 300 pounds per square inch. Hydrogen is admixed with the hydrocarbon vapor.

**U.S.P. 2,325,115. Desulphurizing Hydrocarbon Distillate.** Gustav Egloff to Universal Oil Products Company.

A stream of sulfurous hydrocarbon oils is continuously passed through a heating zone, while adding to it 0.1 to 5.0 percent of fresh finely divided desulfurizing catalyst, consisting of alumina, alumina supporting small amounts of chromia or compounds of a metal of the left-hand column of groups 4, 5 and 6 of the periodic table. The stream is subjected to desulfurizing conditions (500 to 850° F., 100 to 2000 pounds per square inch and subsequently separated into vapors and a residue containing partially spent catalyst. A sufficient quantity of the residue is recycled to maintain in the oil stream a catalyst concentration of the order of 5 to 25 percent.

**U.S.P. 2,327,547. Refining of Petroleum Oils.** H. C. Paulsen to Standard Oil Development Company.

The lead sulfide formed in the doctor-sweetening process settles, due to its finely divided state, only very slowly after the product has been sweetened. The lead sulfide can be removed by washing the sweetened stocks with aqueous solutions of salts of thiazole compounds, preferably alkali metal salts of mercaptoaryl thiazole compounds such as the sodium salt of mercapto benzothiazole and its related derivatives. Reaction conditions are atmospheric to 30 pounds pressure and 30 to 120° F. The amount of thiazole salt recommended is from 10 to 80 mg per 100 ml of aqueous solution.

**U.S.P. 2,328,760. Treating Hydrocarbon Oils.** H. H. Walker to The Texas Company.

An improvement in doctor treating is claimed by substantially increasing rate and efficiency of the separation of suspended impurities, particularly of lead sulfide from a doctor treated oil. For this purpose there is introduced a small amount of steam into the stream of oil passing to the final settlers. About 3 pounds per minute of steam are injected for a naphtha flow of about 250 to 400 barrels per hour.

**U.S.P. 2,329,615 and 2,329,616. Process for Sweetening Hydrocarbon Oil.** C. O. Hoover to Air Reduction Company.

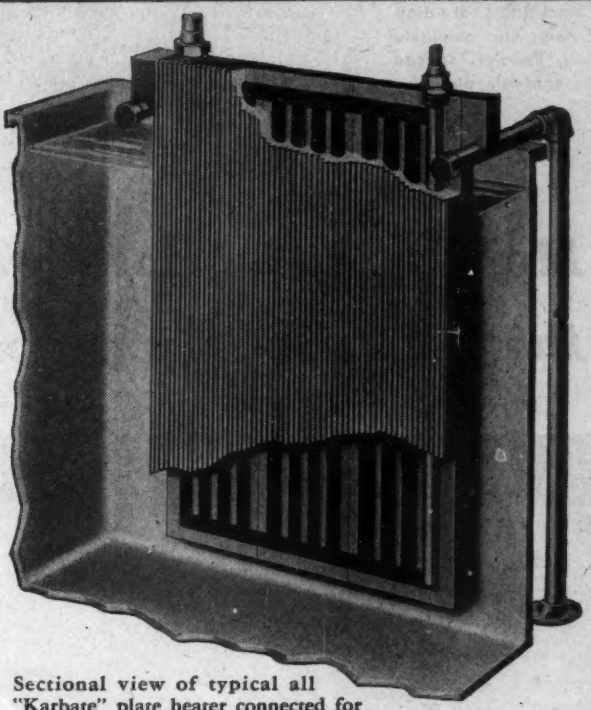
In a process for sweetening hydrocarbon oil in which the oil is contacted with solid alkali metal hydroxide under conditions which result in the formation of an alkali metal monosulfide as a product of the reactions involved in the treatment of the oil, the improvement is claimed which comprises performing said contact while the oil is in the liquid phase and in the presence of added, ex-

# For Greater Serviceability

## KARBATE
TRADE-MARK

## PLATE HEATER

The "Karbate" Plate Heater is a new departure in heaters for pickling tanks, plating tanks or other services where heating, or cooling, of corrosive liquids is required. For greater serviceability through increased resistance to mechanical shock, special construction combines tubular channels in unit blocks of "Karbate" corrosion-resistant material.



Sectional view of typical all "Karbate" plate heater connected for parallel flow. Note assembly of three basic units to specified size and "Karbate" shoulders for support of heater. Other types of supports are available.

### Features of the "KARBATE" Plate Heater

- **"Karbate" material is chemically inert . . . resists practically all acids, alkalies and solvents.**
- **Thermal conductivity of "Karbate" equipment is higher than that of most materials used for such installations.**
- **Fluted sides utilize principles of extended surface for greater heat transfer.**
- **Channels can be arranged in parallel or series flow for heating or *cooling* liquids.**
- **No dilution of tank contents.**
- **Sturdy construction minimizes maintenance costs.**

The "Karbate" Plate Heater is available in four separate design groups and 30 different combinations to meet almost any service requirement. Our representative will be glad to furnish details. Write National Carbon Company, Inc., Cleveland 1, Ohio, Dept. 30F.

The registered trade-mark "Karbate" distinguishes products of National Carbon Company, Inc.

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UNITED STATES
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## NATIONAL CARBON COMPANY, INC.

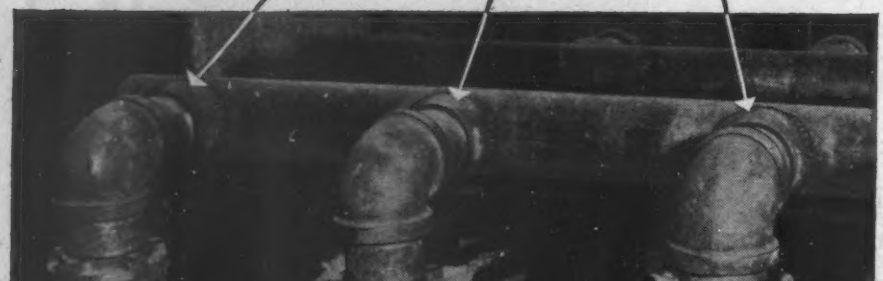
*Unit of Union Carbide and Carbon Corporation*

UCC

CARBON PRODUCTS DIVISION, Cleveland 1, Ohio, New York, Pittsburgh, Chicago, San Francisco

WeldOlets are available in three types—with Welding Outlet, Threaded Outlet (illustrated at right) and Socket Outlet. Stock fittings are drop forged steel. Also available in Monel, Everdur, Toncan Iron, Wrought Iron, etc.

**Here's the simple way to install branch pipe outlets**



● On this piping installation the three branch pipe outlets were installed quickly and easily by the WeldOlet method. The elimination of any templates or the need for any cutting, forming or fitting, speeded and simplified the installation.

These drop forged fittings reinforce the junction so that the original strength of the main pipe is maintained. In addition, the extra large funnel-shaped opening, in the fittings where they join the pipe, cuts pressure loss and reduces turbulence and friction. The WeldOlet method is speedy and low in cost for both size to size or reducing branch pipe outlets. Size to size and reducing sizes are available from ¼" to 12". For complete information write for Branch Pipe Outlet Catalog WT31.

ARMY E NAVY

*Forged Fittings Division*

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WELDOLETS
TRADE MARK REG. U. S. PAT. OFF. PAT. IN U. S. & FOREIGN COUNTRIES
WELDING OUTLET - THREADED OUTLET - SOCKET OUTLET
For Welded Branch Pipe Outlets

traneous uncombined oxygen and a salt of a metal which forms water-soluble sulfides, said contact taking place at a temperature not exceeding about 120° F.

**U.S.P. 2,329,930. Process of Sweetening Hydrocarbon Distillates.** H. J. Nebeck to Universal Oil Products Company.

A copper sweetening process is described which comprises passing a mixture of sour hydrocarbon oil, oxygen-containing gas and finely divided copper-sweetening agent through a sweetening zone of restricted cross section, discharging the mixture into a zone of enlarged cross section maintained within a second enlarged zone, separating and removing residual gas, discharging the substantially gas-free mixture into said second zone, separating and recovering treated oil therefrom, concentrating the used treating agent as a slurry in the remaining relatively minor portion of the treated oil, continuously withdrawing the slurry and supplying it to the first metioned sweetening zone. The copper-treating agent may consist of a finely divided support like fuller's earth, bentonite, pumice, kaolin, etc., impregnated with a suitable copper salt. The reagent should contain 10 percent or less of water. It should be ground to 200 mesh; 10 percent of treating agent by weight of gasoline and 5 to 8 cubic feet of air per barrel of gasoline are used.

**U.S.P. 2,330,735. Process for Refining Sulphur Containing Hydrocarbon Oils.** H. C. Paulsen to Standard Oil Development Company.

Sour petroleum distillates are sweetened in a process which comprises intimately contacting them with an aqueous NaOH solution containing a minor amount of cupric hydroxide and lead sulfide until a substantial reduction in the sulfur content of the distillate is obtained, separating the distillate of reduced sulfur content from the aqueous solution containing reacted cupric hydroxide and lead sulfide and subjecting the thus used solution to controlled regeneration with oxygen containing gas to regenerate the cupric hydroxide.

**U.S.P. 2,331,343. Refining of Mineral Oils.** G. E. Phillips to Standard Oil Development Company.

Objectionable sulfur compounds are removed from a petroleum oil by passing it through a bauxite treating zone in either liquid or gaseous phase and removing the exothermic heat of reaction by introducing a cooling fluid at a plurality of stages in the bauxite treating zone. The total amount of water introduced as cooling fluid should not be greater than 0.5 percent based upon the quantity of the oil treated per time unit.

**U.S.P. 2,334,549. Refining Mineral Oils.** G. R. Gilbert to Standard Oil Development Company.

Mercaptans are removed from petroleum oils by contacting them in an initial stage with an excess of sodium plumbite solution under conditions to form basic lead mercaptides. The treated oil is separated from partly spent sodium plumbite solution and distilled in a secondary stage in the absence of steam and under vacuum at a temperature below 250° F. A distillate free of mercaptides is removed overhead and a relatively small quantity of higher-boiling oil constituents containing dissolved basic lead mercaptides is removed as

# *Ever try solving 54 simultaneous equations?*

REMEMBER the complexity of the simple simultaneous equations of your high school algebra . . . involving but 2 unknowns?

Then you'll really appreciate what mechanical engineers accomplish in establishing the accurate design and specifications for the labyrinths of piping in a modern refinery.

The required piping calculations for even a run-of-the-mill job—involving 18 unknowns—test the mettle and patience of the industry's mathematical specialists. But only M. W. Kellogg can supply the accurate answers to 54, 60 or even 72 simultaneous equations—covering up to 12 points of fixation—as part of its engineering *routine*.

For this purpose, our engineers harnessed electricity and the scale model—evolving an apparatus which is sensitive to deflections of a *millionth of an inch*—to determine the actual stresses and reactions on the full-scale job. The electrical measuring instruments which make possible such accuracy were developed by us . . . are the only ones in existence!

This exclusive apparatus saves our clients untold thousands of dollars. Piping systems in Kellogg-designed refineries are neither over- nor under-built.

Handling piping systems with characteristic extra skill is just another reason why Kellogg mechanical engineers were selected to design over two-thirds of today's Fluid "Cat-Cracking" capacity. But these men—and their experience and equipment—are only one important phase of M. W. Kellogg Complete Service. We evolve the required engineering data. We apply it. We develop process methods. We design. We build. We supervise initial operation. And the finished job must meet a two-fold aim: Total war production now . . . a head-start in postwar competition for our clients.

# *THE* M. W. KELLOGG COMPANY

***Only Kellogg Service Has Them All***

★**LABORATORIES**—fully equipped and staffed—devoted exclusively to chemical engineering and process development.

★**24-HOUR-A-DAY PILOT PLANTS**—17 refining processes operating continuously—providing accurate data for commercial scale application.

★**EXCLUSIVE CHEMICAL ENGINEERING DATA**—Continuously compiled . . . embracing both pilot plant runs and the operation of Kellogg-built refineries. Data extends from beginning of modern refining.

★**PROCESS ENGINEERS**—Specialists who have continuously made major contributions to oil refining development, for more than 20 years . . . currently exemplified by their work on fluid catalytic-cracking.

★**MECHANICAL ENGINEERS**—Kellogg installations—worth hundreds of millions—are their best reference.

★**METALLURGICAL LABORATORY**—Establishes continuous check of specifications...creates new techniques for the fabrication of refining equipment.

★**PERMANENT CONSTRUCTION CREWS**—Geared to function all over the world on single units or multiphase refineries . . . team-experience cuts costs, speeds construction.

★**OPERATING STAFFS**—Specialists at placing new units "on stream" . . . training of refiner's own operating crews.

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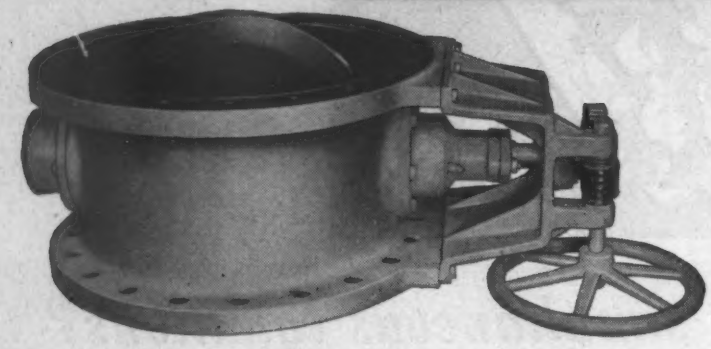
# HOW TO ORDER
## R-S Cast Steel Butterfly Valves

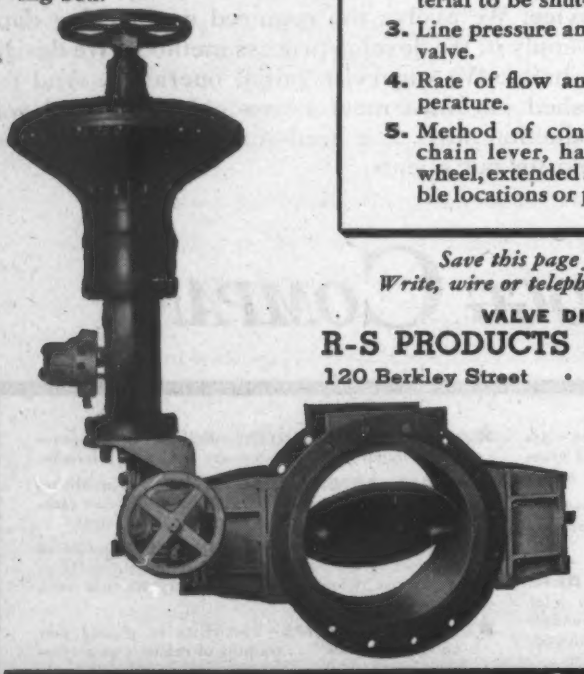
**No. 53**
150-pound steel valve with raised face. Hand wheel operated. Extra rugged construction.



R-S Cast Steel Butterfly Valves are divided into two classes. Class A are lightweight, close coupled 15-pound valves with series 15 flanges. For limited pressure drops, ball bearings can be used. Class B are constructed for heavy duty service. The face-to-face dimension is greater than that of Class A valves, permitting the installation of oversized shafts, bearings, stuffing boxes, etc. for higher working pressures and temperatures.

In ordering any R-S Butterfly Valve, regardless of type, class or service for which it is to be used, it is essential to furnish the following information:

**No. 610**
Heavy-duty air motor operated steel valve equipped with hand jack, mercury switch, hand wheel declutching unit and dual stuffing box.



1. Size of valve and type of flanges.
2. Nature of gas, liquid or other material to be shut-off or controlled.
3. Line pressure and pressure loss in valve.
4. Rate of flow and operating temperature.
5. Method of control (hand lever, chain lever, hand wheel, chain wheel, extended shaft for inaccessible locations or power operation).

*Save this page for reference.*
*Write, wire or telephone for fast service.*

VALVE DIVISION
**R-S PRODUCTS CORPORATION**
120 Berkley Street • Philadelphia 44, Pa.

**15 to 900 psi**

R-S Streamlined BUTTERFLY VALVES


bottoms. The lead compounds are removed and combined with partially spent sodium plumbite solution which is then recycled.

**U.S.P. 2,335,347. Method for Removing Weakly Acidic Sulfur Compounds from Hydrocarbon Oil.** T. L. McNamara to The Pure Oil Company.

If spent caustic alkali solution from the treatment of hydrocarbon oils containing phenolic and/or naphthenic acid substances is neutralized and the acid oil obtained from the neutralization of the spent alkali solution is carefully concentrated at temperatures where decomposition of the acid oil does not take place, the residuum oil is highly efficacious, when dissolved in caustic alkali solution, in the removal of acidic sulfur compounds from hydrocarbon oils and distillates. Contact temperatures should not exceed 350° F. The concentration of free alkali in the caustic solution should be at least 5 percent.

**U.S.P. 2,336,109. Process for Sweetening Gasoline.** C. D. Lowry, Jr., and R. E. Sutherland to Universal Oil Products Company.

Gasoline is sweetened by contacting it with an aqueous solution of an alkali metal hydroxide at 50 to 100° F., recovering the solution and regenerating it, separating the gasoline, mixing it with sodium plumbite solution, adding thereto sufficient sulfur to bring about the sweetening reaction, further mixing the mixture, removing a major portion of the spent doctor solution, contacting the sweetened gasoline with an additional portion of fresh doctor solution, separating the gasoline and removing remaining treating solution therefrom, subjecting spent doctor solution to reactivation in the presence of air and recycling it.

**U.S.P. 2,336,174. Process for the Removal of Mercaptan Compounds from Petroleum Oils.** A. P. Hewlett to Standard Oil Development Company.

To remove mercaptans, petroleum oils are segregated into a low-boiling fraction (100-225° F.) and a high-boiling fraction (200-425° F.). The relatively low-boiling fraction is contacted with an alkali metal hydroxide solution, while the relatively high-boiling fraction is contacted with bauxite. Both fractions are then combined. The total oil can also be treated first with the alkali metal hydroxide solution followed by beauxite treatment. The treat solution should have a concentration of 10-15° Bé. The beauxite is activitated at 600 to 800° F. It may be of any particle size, but powdered beauxite is preferable. Feed rates are from 1 to 7 volumes of oil per volume of beauxite per hour.

**U.S.P. 2,336,651. Removal of Sulfur Compounds Utilizing Alkali Metal Phosphate solutions and Process for the Regeneration of Same.** R. K. Stratford to Standard Oil Development Company.

Hydrogen sulfide is removed from petroleum hydrocarbons by absorbing it in a solution of alkali metal phosphate and particularly of tripotassium phosphate, free from phenolic compounds. The spent absorption solution is mixed with a phenol and the mixture distilled under conditions to segregate hydrogen sulfide, substantially phenol-free alkali metal phosphate solution and substantially pure phenol. The phenol, preferably monohydroxy phenol, may be con-

# McALEAR MANUFACTURING CO.
# HANLON-WATERS INC.

## now One!

*An Announcement of Major Significance to every user of Automatic Control Instruments*

HENCEFORTH, McAlear and Hanlon-Waters will function as divisions of *one* company. This brings together the leading supplier of automatic control instruments for the oil field and the foremost producer of similar devices for heating and industrial service.

Hanlon-Waters products will continue to be available to the oil field from the Tulsa plant, under the same management and engineering supervision as heretofore.

McAlear, whose products have for a third of a century dominated the process, industrial and heating fields, will continue to operate out of Chicago.

Customers of each company will benefit from this pooling of patents, designs and—*engineering experience.* The Hanlon-Waters oil field line of automatic controls, separators and tanks, will be immediately supplemented by such McAlear controls as the combined engineering staffs of the two companies regard to be best for such service. Similarly, the McAlear line will be complemented by outstanding features and products of Hanlon-Waters manufacture.

This affiliation provides unmatched manufacturing, engineering and research facilities. The new leadership thus established will find quick expression in new control developments (some already well under way) which will pace future industrial progress.

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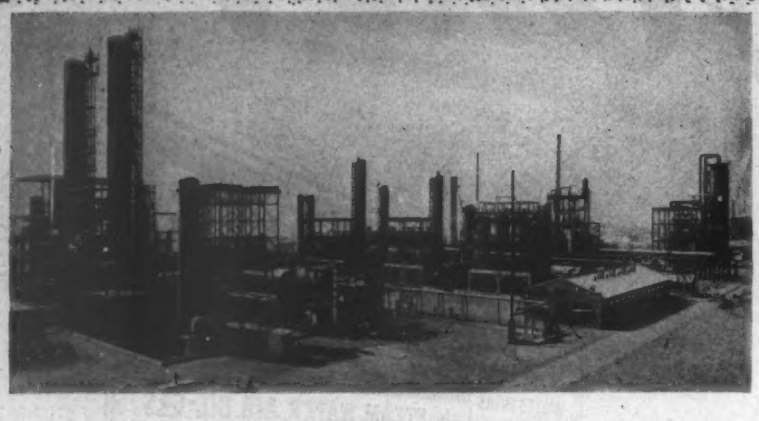

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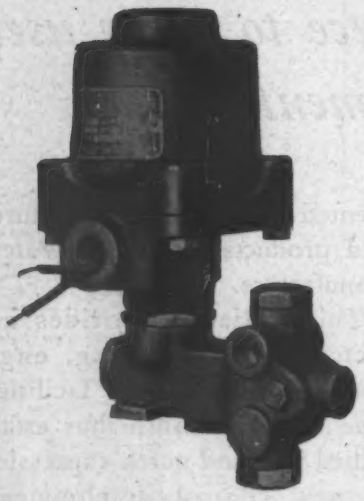

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centrated to a predetermined volume, depending on the extent to which the absorption solution has been spent, and then treated with steam, giving hydrogen sulfide and substantially phenol-free regenerated alkali metal phosphate solution.

**U.S.P. 2,336,896. Utilization of Foul Steam for Hydrogen Sulfide Removal.** W. H. Shiffler and L. P. Elliott to Standard Oil Company of California.

The foul mercaptan-containing steam from the regeneration of aqueous alkali solutions used in removing mercaptans from gasoline, which is normally wasted, can instead be employed to regenerate treating solutions used to remove hydrogen sulfide from hydrocarbons. There is substantially no absorption of the mercaptans in the hydrogen sulfide absorption medium being regenerated and there is no pollution of the hydrocarbons from which hydrogen sulfide is being removed by mercaptans.

**U.S.P. 2,337,225. Method for Reconditioning Used Solutizer Solutions.** L. E. Border to Shell Development Company.

Resinous emulsifiers which accumulate in used solutizer solutions may be removed by subjecting the alkaline solutizer solutions to a treatment with flocculent solids, rendering the solution clean and again suitable for use in the solutizer process. Suitable flocculants which are less than 1 percent soluble in water at room temperature are hydroxides of magnesium, calcium, cadmium, copper, chromium, iron and nickel, carbonates and phosphates of alkaline earth metals and lead and the sulfates of calcium, barium and lead when in floccular form. Solutizer solutions at the time of the treatment should contain alkali metal hydroxide in a concentration of not more than 3N.

**U.S.P. 2,337,262. Process for Completely Regenerating Contaminated Solutizer Solutions.** R. M. McOmie, O. L. Davis and A. C. Nixon to Shell Development Company.

Solutizer solutions accumulate resinous emulsifiers in the course of repeatedly treating hydrocarbon distillates. These emulsifiers are removed as solids by neutralizing the solution with $CO_2$ to produce a carbonated liquid, and after removing precipitated solids by recausticizing. at least a portion of the carbonated liquid. The concentration of the alkali metal hydroxide should be between 2.5 and 0.5 N and the recaustizing is carried out with lime.

**U.S.P. 2,337,358. Treatment of Hydrocarbons.** A. Szayna to A. C. Travis.

Oils are desulfurized by heating them to a temperature of about 700° F., decomposing sulfur compounds of the oil by passing the heated oil over a porous mass comprising nickel, a substantial portion of which is combined with sulfur, separating the oil from the mass before all sulfur is removed from the oil and cooling to below 650° F. The remaining sulfur is removed by contacting the oil below 650° with a porous mass comprising nickel in highly active extended surface form.

**U.S.P. 2,337,467. Refining Mineral Oils.** A. P. Hewlett to Standard Oil Development Company.

Oils in the gasoline to gasoil boiling range are treated with alkali metal hydroxide solution, utilizing a new se-

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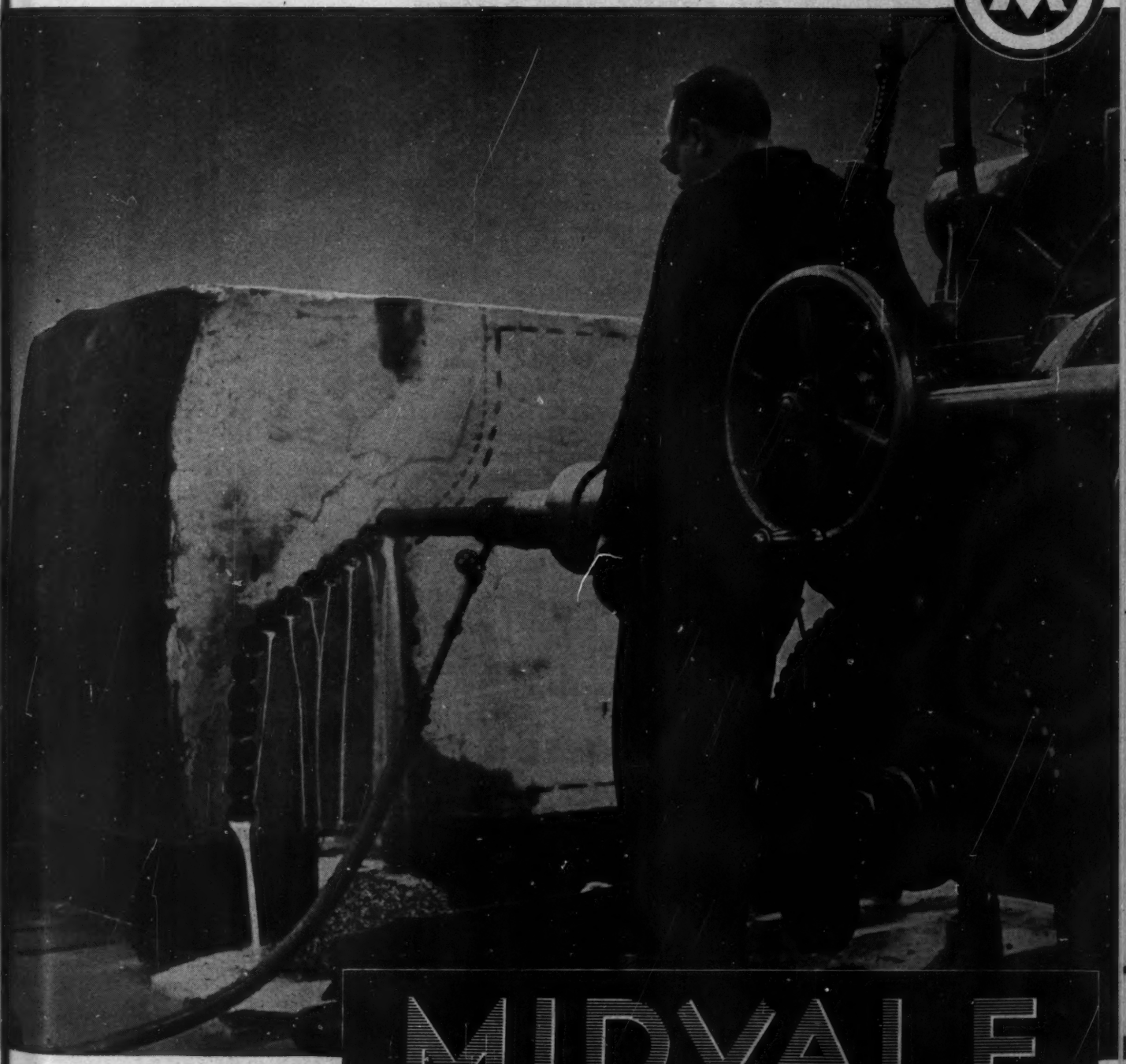

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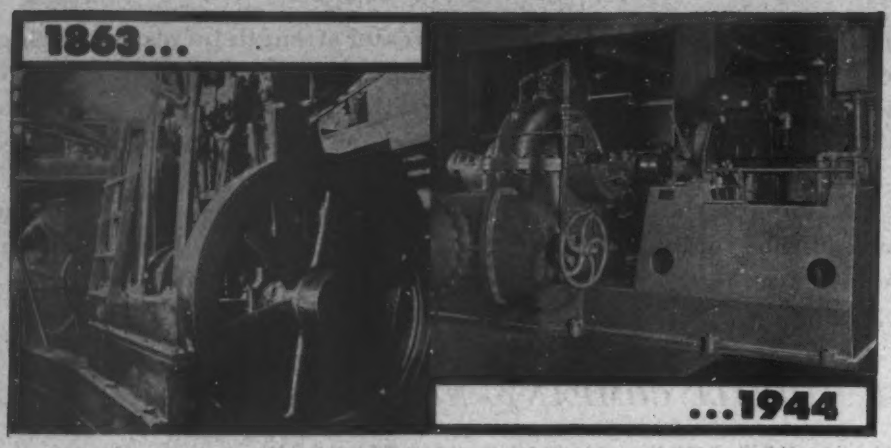


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quence and arrangement of stages by which desirable acidic constituents, such as phenolic gum inhibitors are retained in the oil while objectionable acidic constituents are removed. Hydrogen sulfide and naphthenic acids are removed in a first zone by treating with aqueous caustic soda of 10-20° Bé in proportions of about 1 part to 100 parts of oil. The caustic soda solution contains dissolved a sufficient amount of soda salts of petroleum phenols so as not to remove phenols from the oil. Hydrogen sulfide is removed in the second zone with aqueous caustic soda solution of the same strength and composition applied in a proportion of 25 parts per 100 parts of oil. The solutions are then regenerated.

## Urge Midwest Plants To Use More Sour Crude

Increased use of crude oils from West Texas and Wyoming was urged upon refiners in the Middle West (PAW District 2) by Paul Blazer, District 2 refining chairman, at a meeting of 80 refiners from the area at Chicago May 12. Use of such oils is necessary if runs are maintained at a minimum of 1,225,000 barrels daily, it was pointed out, and unless output is maintained it eventually will result in a directive.

PAW's policy, it was revealed, is that it is better to have some plants operating at less than capacity than to have any shut down, and therefore a crude-sharing plan is necessary.

Completion in recent weeks of substantial additions to line capacity out of West Texas, connecting to existing lines into District 2 and east, and also shortening rail haul when such movement is required, will make more of such oil available to Middle West refineries. Production ordered by PAW for June increased Texas output 59,000 barrels daily, 15,000 barrels of which is sour oil from West Texas, to which is added 1300 barrels more from New Mexico.

## Cities Service Company Will Retain Oil Business

Cities Service Company, ordered by the Securities and Exchange Commission to divest itself either of its utility or oil interests, has announced intention to get rid of its utilities.

Cities Service Oil Company, subsidiary of Cities Service Company, for its own account and through subsidiaries, operates seven refining plants in the United States. Other units carry on producing and transportation activities in connection with the parent company's natural-gas distribution activities.

It has been indicated that more than half of the company's gross business is in the oil and gas industry.

## Carthage Gasoline Plant Nearly Ready to Operate

The Carthage, Texas, gasoline extraction plant of Arkansas-Louisiana Gas Company and the field gathering lines are nearing completion and the plant will begin operation about June 1, company officials have announced.

The plant will process about 25 million feet of gas daily from the Panola County fields, extracting the gasoline and petroleum by-products before the gas is turned into company mains for distribution for fuel.

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# SCIENCE AND TECHNOLOGY

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*under the supervision of*

DR. E. H. LESLIE and DR. H. B. COATS

*The abstracts here presented are selected from the current literature of science and technology to afford reference to fundamental information not easily available to all readers. Abstracts of articles appearing in readily obtainable trade journals are not included.*

*Photostat copies of original articles will be supplied at cost by the Leslie Laboratories. Complete or limited bibliographies covering special topics by title, by abstracts, or in complete manuscript, will also be prepared and furnished at reasonable cost by the Laboratories.*

## Fundamental Physical And Chemical Data

**Phase Equilibria in Hydrocarbon Systems.** H. H. REAMER, R. H. OLDS, B. H. SAGE, AND W. N. LACEY. *Ind. & Eng. Chem.* **36** (1944) pp. 381-83.

Quantitative information regarding the behavior of water in association with petroleum hydrocarbons under the conditions found in natural reservoirs is of engineering value because of the extensive occurrence of water in petroleum reservoirs. The work reported covers an experimental investigation of the three-phase region of the n-butane-water system at temperatures above 100° F. It represents part of a more extensive study of this system now in progress, which investigation will cover temperatures up to 460° F. at pressures as high as 10,000 pounds per square inch. The slight miscibility of liquid hydrocarbons with water favors the occurrence of coexisting liquid phases, and they should be expected in the n-butane-water system at temperatures below the critical temperature of n-butane. The phase rule indicates that a two-component system can have no more than four phases coexisting in equilibrium. In the case of the n-butane-water system it is likely that at least one such quadruple point exists, composed of a solid phase in equilibrium with two liquid phases and a gas phase. However, the temperatures at which this investigation was conducted were somewhat higher than those at which the solid hydrocarbon hydrates are known to exist, and only three coexisting phases were observed. The data secured in the work are presented in detail in tabular form, and also diagrammatically. A phase diagram for the n-butane-water system at 280° F. is shown. Another diagram shows the composition of coexisting phases in the three-phase region. A bibliography of 17 references is included.

**Gas Solubility and Partial Pressure.** D. F. OTHMER AND R. F. BENENATI. *Ind. & Eng. Chem.* **36** (1944) pp. 375-77.

The fact that data for gas solubility can be reduced to a representation as straight lines, as reported in a previous paper by the authors, suggested that one of the most easily constructed forms of nomograms could be drawn to enable the ready use of the values. The construction of such a nomogram is described. Water is utilized as a reference substance.

**New Methods for the Calculation of the Heat of Evaporation.** R. SCHUMACHER. Oel u. Kohle **39** (1943) pp. 634-9.

A general equation for calculation of the heat of evaporation for an external pressure of 1 atmosphere was given in which a quantity $V_s$, the apparent molecular volume of the liquid under consideration gives $Mr = RT \ln RT/V_s$ in which M is the molecular weight, R is gas content, and T is the absolute boiling point. $V_s$ is constant for entire classes of compounds and can be calculated from the available data on heats of evaporation. The lines for $V_s$ of various groups of compounds represent the perimeter in the diagram in which Trouton's constant is plotted against log T and are straight lines. The values for the different series are given: paraffins, isoparaffins, olefins, napthenes, aromatic compounds, respectively (cc./mol.): 1.2, 1.1, 0.7, 0.9, 0.8. Data are also given for aliphatic alcohols, aldehydes, ketones and ethers and chlorinated aliphatic and aromatic hydrocarbons. For pressures other than 1 atmosphere the equation is modified as follows: $Mr = RT \ln RT/V_s p^s$. The exponent s was derived theoretically and values for paraffins were determined empirically. A diagram is given showing the relation of the molecular heat of evaporation at various temperatures and pressures for paraffins up to C30.

**Viscosity and Structure of Pure Hydrocarbons.** H. A. KIERSTEAD AND J. TURKEVICH. *J. Chem. Phys.* **12** (1944) pp. 24-7.

The authors tabulate the constants A and E in the equation for fluidity $\alpha = A^{-E/RT}$ for the normal paraffins from C through $C_{12}$, $C_{14}$, $C_{16}$, $C_{18}$ and $C_{22}$. Constants are also given for benzene, toluene, ethylbenzene, butylbenzene, and for several compounds of iso structure as well as olefins. Data are also given for cyclopentane, methylcyclopentane, cyclohexane, methylcyclohexane, dimethylcyclohexane, o-xylene, biphenyl, decahydronaphthalene, 1, 2, 3, 4-tetrahydronaphthalene and naphthalene. The manner of the variation of these constants with structure is discussed.

**The Relation Between Surface Tension and Vapor Pressure of Liquids and Liquid Mixtures.** R. C. TRIPATHI. *J. Indian Chem. Soc.* **20** (1943) pp. 197-9.

The author proposes an equation of the type $p = A + (B/(C - y))$, in which p is the vapor pressure, y is the surface tension of the liquid, and A, B and C are constants, and shows that this equation represents the variation of surface tension of unassociated or associated, organic and inorganic liquids with vapor pressure. The equation also represents the change of surface pressure of binary liquid solutions of constant composition with vapor pressure. The data, presented in tabular form, indicate that the equation is quite satisfactory.

**Hyperconjugation in Paraffin Hydrocarbons.** G. W. WHELAND AND J. T. PINKSTONK, JR. *J. Chem. Phys.* **12** (1944) p. 69.

The heats of combustion of the normal paraffin hydrocarbons are related to the number of carbon atoms in the molecule in a linear manner. The authors show that resonance energies due to hyperconjugation have no significant effect on this approximate linear relationship, and that they cannot account for the observed deviations from linearity.

## Chemical Compositions And Reactions

**Oriskany Natural Gas.** A. J. W. HEADLEE AND J. L. HALL. *Ind. & Eng. Chem.* **36** (1944) pp. 299-303.

The Oriskany sand extends over the greater part of the northern half of the Appalachian Geologic Province and includes most of West Virginia, western Pennsylvania, the eastern border counties of Ohio, and several counties of New York north of Tioga County, Pennsylvania. Several natural gas fields have been discovered in this sand. The largest has produced about 600 billion cubic feet of gas. The Kanawha-Jackson County Oriskany field produced about 110 billion cubic feet of gas during 1942. The original reservoir pressure was 1800 to 2000 pounds per square inch. It is therefore a distillate structure; that is, retrograde condensation

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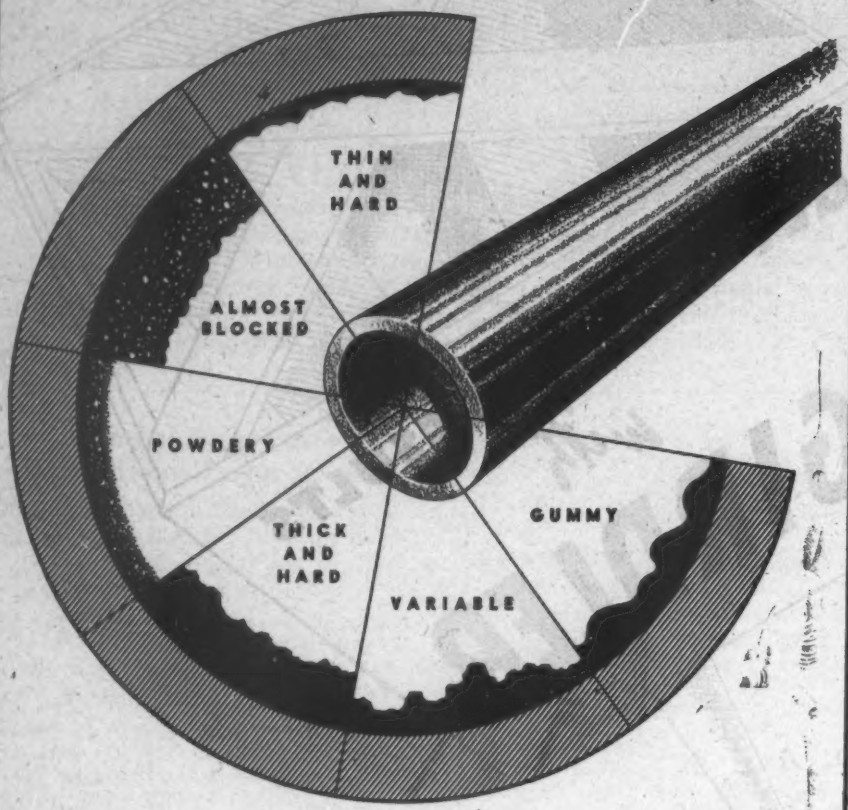


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takes place as the reservoir pressure declines. Large quantities of clear condensate are produced by these wells. Most of the analytical data presented in the article cover products from this field. Samples represent the gas phase produced at the wellhead. The gas consists of methane, ethane, propane, iso- and n-butanes, iso- and n-pentanes, hexanes, heptanes, and higher-boiling hydrocarbons. Large reserves of these compounds are available for chemical industries. The areal composition varies from almost pure methane along the eastern border of the sand to gases that contain a total of 12 to 15 percent of ethane and higher-boiling hydrocarbons associated with some 85 percent of methane along the center of the geosynclinal basin. A map showing the location of the fields is given, and analyses of gases from typical wells are tabulated. Detailed analyses of individual samples from various fields are given in tabular form. The operating status of various wells in the field is tabulated. Large acreages in the field are free of hydrogen sulfide, but this substance occurs in small amounts in several of the gas fields in the Oriskany area. Combination desulfurization-dehydration plants are used to remove hydrogen sulfide and sufficient of the water to prevent hydrate formation at pipe line maximum pressures and minimum temperatures. Some data are included on the analyses of the condensate obtained in the field.

**The Reaction of Hydrogen Atoms with Propylene.** B. S. RABINOVITCH, S. G. DAVIS AND C. A. WINKLER, *Can. J. Res.* **21B** (1943) pp. 251-7.

In reacting hydrogen atoms with propylene the technique employed was the same as that previously used for reacting hydrogen atoms with isobutane. Methane was produced to the extent of 0.64-0.76 moles per mole of $C_3H_6$ treated. Ethylene and propylene were not formed. The reaction products were virtually independent of temperature. The primary and secondary reactions involved are discussed. The authors believe that the activation energy in the primary step in the propylene reaction is 5 kg.-cal. or less.

**Hydrocarbon Polymerization and a New Method of Determining Catalyst Activity.** R. F. CANE. *Australian Chem. Inst. J. & Proc.* **10** (1943) pp. 279-86.

The author describes a method for determining the activity of phosphoric acid catalysts by measuring the heat evolved when polymerizing a-phellandrene under standard conditions. The effects of oxygen and nitrogen compounds, as well as mercaptans on the catalyst activity were studied.

**Bicyclo (2,2,1) Heptane and Bicyclo (2,2,1)-2-Heptene.** C. L. THOMAS. *Ind. & Eng. Chem.* **36** (1944) pp. 310-11.

Bicyclo (2,2,1)-2-heptene is formed by heating technical dicyclopentadiene with ethylene in a bomb at 200° C. and at pressures up to 120 atmospheres. Presumably the dicyclopentadiene depolymerizes to cyclopentadien, and this substance reacts with the ethylene under the reaction conditions to give bicycloheptene. Bicyclo (2, 2, 1) heptane is formed by hydrogenating the bicycloheptane at 50° C. in the presence of a nickel catalyst. Some methylcyclohexane is formed simultaneously. Both of the

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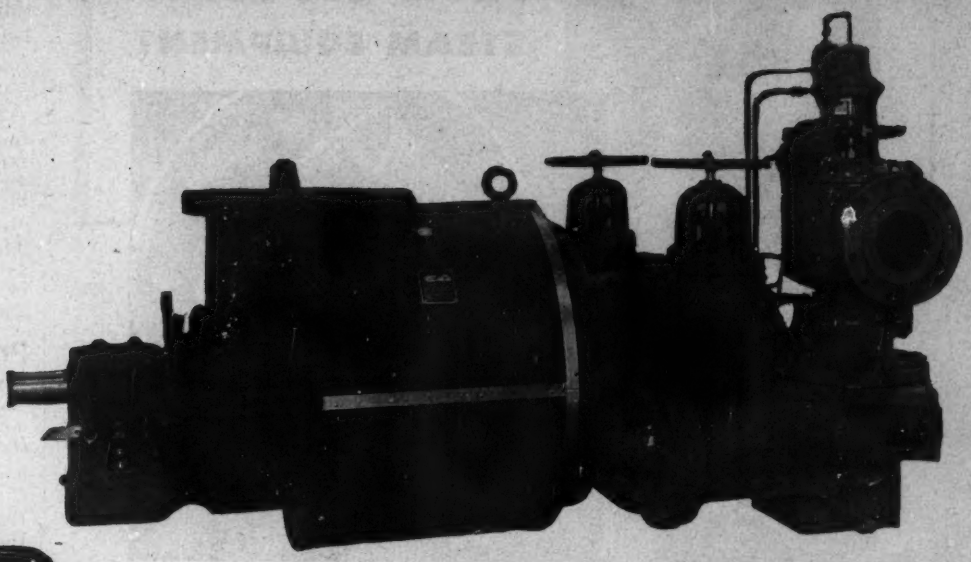

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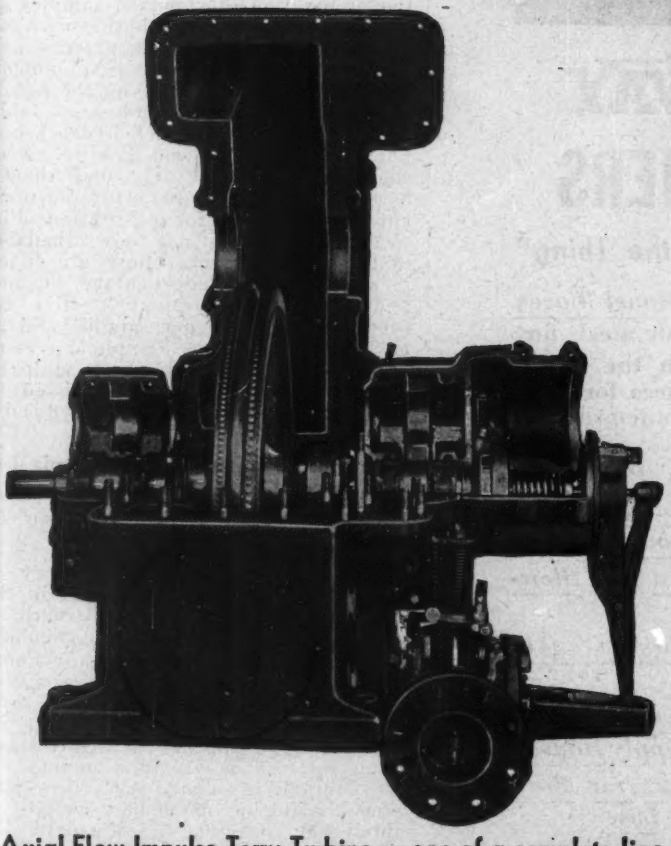

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bicyclo compounds are white crystalline solids. A.S.T.M. octane numbers were determined on blends of 2,2,4-trimethylpentane, n-heptane, and the hydrocarbons. The bicycloheptene has a blending octane number of 95 ± 5; the bicycloheptane, a blending octane number of 56 ± 5.

**The Nitrogen Compounds in Petroleum Distillates. XXV. Isolation and Identification of 3- and 4-Cyclopentylpyridines from California Petroleum.** H. L. LOCHTE, E. D. THOMAS AND P. TRUITT. *Jour. Amer. Chem. Soc.* **66** (1944) pp. 550-52.

In an extension of a study of California petroleum bases boiling in the range of 210-213° C., 3-cyclopentyl- and 4-cyclopentylpyridine were isolated and identified. 2-, 3- and 4-cyclopentylpyridine were synthesized and characterized. The methods used in the work are described in some detail and the properties of the various compounds are given.

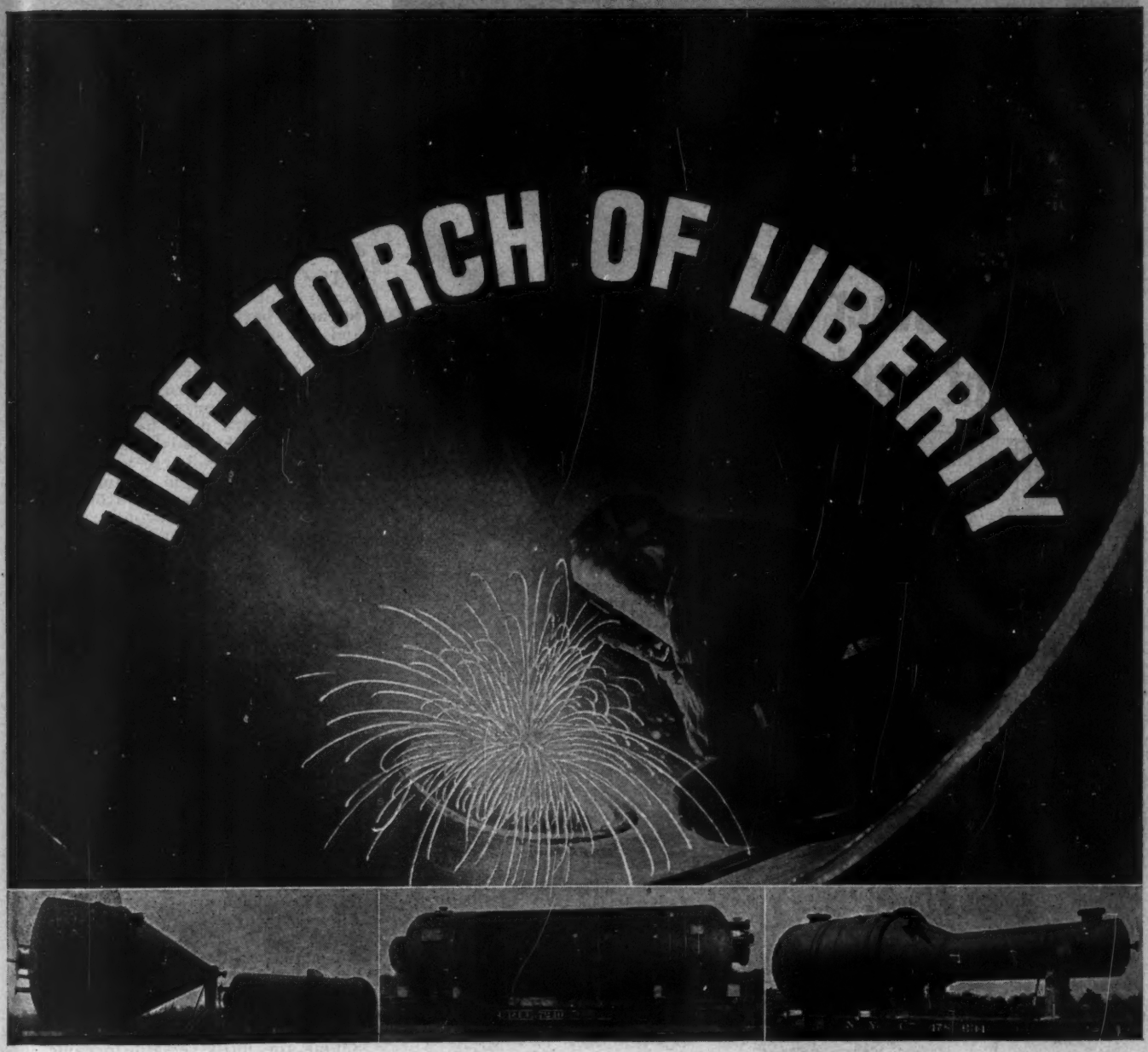
## Products: Properties And Utilization

**Standard Samples of Hydrocarbons.** *Ind. & Eng. Chem.*, Anal. Ed. **16** (1944) p. 273.

Work was begun at the National Bureau of Standards on July 1, 1943, on the preparation of standard samples of hydrocarbons of known high purity for calibrating analytical instruments and apparatus in the research, development, and analytical laboratories of the petroleum, rubber, and allied industries. Only a limited quantity of each hydrocarbon has been prepared and the purity of each has been made only such that it is believed to be adequate for the present urgent needs for calibration. Fifteen hydrocarbons are now abailable under this program. These are listed in a table and include pentane, hexane, and the simpler aromatics. Five cc. samples cost $3.00 per sample, and 25 cc. samples, $9.00 per sample. Payment for the samples must be made with the order, which should be addressed to the National Bureau of Standards, Washington 25, D. C.

**Optical Rotation of Pennsylvania Lubricants.** F. L. CARNAHAN, R. E. HERSH, AND M. R. FENSKE. *Ind. & Chem.* **36** (1944) pp. 333-5.

For some years the laboratory at Penn State has been interested in the identification of lubricating oils with respect to geographical origin, particularly in regard to the detection of non-Pennsylvania material. In the search for identification methods the optical rotations of petroleum fractions were investigated. It appears that the maximum rotatory power in a mineral oil is commonly associated with those portions having a molecular weight of about 400; such material is usually distilled in the refining process and is included in the neutral. The low rotatory power of Pennsylvania oil fractions is of importance. Optical rotations were taken on distillate fractions from seventy-six commercially refined Pennsylvania oils, and in most instances a reading was also taken on the original oil. The group includes one or more neutrals from each known Pennsylvania refiner. The highest rotation noted for any fraction was +0.26. Accordingly,

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it appears that higher values obtained in an equivalent procedure indicate a crude source other than Pennsylvania. The authors also include certain supplementary data on neutral oils prepared from individual well samples of crudes from various geographical sources. The data secured in the work are presented in detail in tabular form.

**The Nitroparaffins. Preparation, Properties and Uses.** Editorial Staff, *The Industrial Chemist,* March (1944) pp. 144-151.

The nitroparaffins constitute a good example of what can be achieved by research backed with adequate funds and the spirit of the pioneer. When he ignored the textbook view of the unreactiveness of the paraffin hydrocarbons, Prof. Haas, of the Purdue Research Foundation, turned what at first sight seemed a most unpromising raw material into the basis of a large chemical development. There are at present four nitroparaffins in commercial production—nitromethane, nitroethane, 1-nitropropane and 2-nitropropane. They are all derived from propane by the vapor phase nitration with nitric acid at a temperature of 400° C. and a pressure of about 10 atmospheres. Nitration of a paraffin hydrocarbon produces nitroparaffins having the same and also a smaller number of carbon atoms. At the same time there are formed olefins, oxides of nitrogen, hydrocarbon oxidation products and water. These must be separated from the nitroparaffins and from the unreacted propane and nitric acid. The crude products are purified by continuous vacuum distillation and fractionation. Nitroparaffins are water-white liquids, the boiling points of which and rates of evaporation fall roughly in the middle of the range covered by the common solvents. Their rates of evaporation correspond roughly to those of butyl acetate and toluene. Their use involves no special risks to health. They have negligible toxicity and explosion hazard; they distill without decomposition at ordinary pressure. Their solubility in water is low. The solutions are weakly acid, pH 3.9-4.3. The nitroparaffins can claim to be among the most versatile organic substances in large-scale production. Their usefulness may be judged by the fact that the entire output of the first plant at Peoria, Illinois, has been taken by essential war industries and another and much larger plant is planned. The property that first stimulated the demand for the nitroparaffins was their remarkable solvent power. They are excellent solvents for a number of materials, including high polymers such as the synthetic rubbers and resins, and cellulose esters. The nitroparaffins are among the best solvents known for copolymers of vinyl chloride and vinyl acetate. Other promising solvent uses of the nitroparaffins include the refining of lubricating oil, the formulation of special spotting fluids for the dry cleaning industry, and for specialty products for paint and varnish removal, especially for the difficult baked synthetic finishes. Nitroparaffins cost more than standard solvents such as acetone, ethyl acetate, methyl ethyl ketone and butanol, and will find their chief outlet where cheaper alternate solvents will not do the work. One feature that helps to compensate for the high price of the nitroparaffins is the high tolerance of their solutions for cheap non-solvent diluents. The opinion has been expressed that nitro-

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paraffins will find their greatest field of usefulness as raw materials in chemical industry. Here their ease and variety of reaction make them suitable starting points for many syntheses. The four classes of compounds made from nitroparaffin on a large scale are the nitrohydroxy derivatives, reduction products, aminohydroxy compounds, hydroxylamine, and chloronitroparaffins. In all, seventeen nitroparaffin derivatives are in commercial production, but each of these substances is a potential starting point for many others. The utilization of the nitroparaffin derivatives is discussed in some detail. Tables are given showing the properties of the nitroparaffins themselves and of several of their derivatives.

**A Study of Petroleum Microcrystalline Waxes.** R. B. KILLINGSWORTH. *Am. Perfumer* 46 (1944) pp. 33-6.

The author considers the properties and uses of the micro waxes and their blends with paraffin, ozocerite, ceresin, beeswax, castor oil and stearic acid. The micro waxes differ from crystalline paraffin waxes, being more ductile, tougher, tackier, of high viscosity, of greater resistance to oxidation, of higher melting points (60-88°P), and of greater ability to retain oil without loss through sweating.

**Properties and Utilization of Petroleum Waxes.** C. G. GRAY. *Jour. Inst. Petr.* 30 (1944) pp. 57-67.

The waxy materials derived from petroleum are classified into three main groups: (1) the paraffin-wax group; (2) the petrolatum group; and (3) the petroleum ceresin group. This classification is based mainly upon crystal size, consistency, and method of manufacture. The properties and applications of each of these three classes of waxes are discussed. The paraffin-wax group is first considered including refined paraffin wax and paraffin scale wax. Melting points, densities, specific heats, latent heat of fusion, electrical resistance, dielectric constant and solubilities are given. The chemical reactions are briefly considered. The paraffin waxes and scale waxes used are consumed to the extent of 64 percent for making candles and tapers, 15 percent for waxed paper and cartons, 10 percent for polishing materials, 5 percent for matches, 3 percent for electrical insulation, and 3 percent for miscellaneous applications. The utilization of these waxes in the production of these products is described in some detail. The petrolatum group of waxes is next considered. These substances have congealing points ranging from 100° to 180° F. and in consistency they vary from salve-like to firm and plastic. Petrolatum wax, which is essentially oil-free petrolatum, is a plastic solid possessing some degree of tackiness and a congealing point of about 190° F. It is used in the impregnation of insulating tape and cable-core wrappings and to some extent for preserving cheeses, hams and perishable foodstuffs. Some of these waxes are used in paper coating and in polish manufacture. The adhesion of petrolatum wax to metal and other surfaces is good. Petroleum jelly, a soft salve-like preparation containing petrolatum wax and oil, is briefly considered. The petroleum ceresin group is considered in the conclusion of the article. These are hard, brittle waxes, usually derived from residues, and are essentially free from oil. The congeal-

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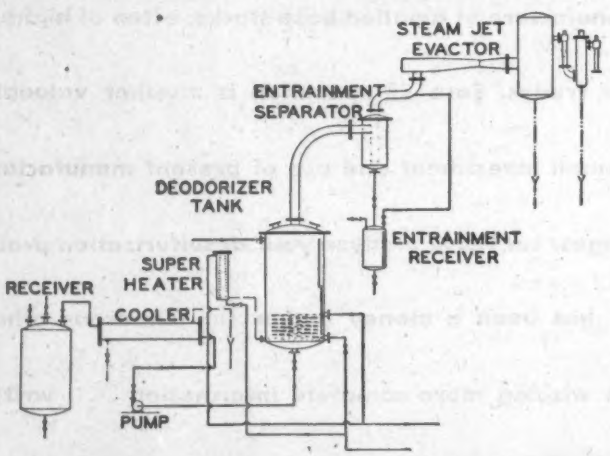


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ing point is usually 160° F. to as high as 205° F. These waxes are normally crystalline, and in color range from white to dark brown. Their applications are briefly considered.

**Standard Methods for Testing Petroleum and Its Products.** 5th ed. 500 pages, 127 diagrams. *Inst. of Petr.*, London, England, and *Amer. Soc. for Testing Materials*, 260 S. Broad St., Philadelphia, Pa., 1944. Price, $3.00.

The new fifth edition of The Institute of Petroleum's handbook contains details of 97 methods for testing petroleum and its products. New methods included are those for determining aniline points of volatile materials, a low-temperature filtration test for gas oil and diesel fuels, the Fraass breaking point test for bitumen, a congealing point test for waxes for which the setting point method is unsuitable, a method for determining the water tolerance of a motor fuel, new distillation tests for crude oil and residues, a method for estimating the salt content of crude oil, and the use of the Abel flash point apparatus for viscous petroleum mixtures and of the N. G. A. A. metal pycnometer for determining the specific gravity of liquefied gases. A.S.T.M. methods, slightly modified, have been adopted for determining the tetraethyllead content of motor fuel and the residue on evaporation of kerosene and tractor fuels. Methods for testing bituminous emulsions and chemicals derived from petroleum are included. The sampling procedures have been completely revised and major changes have been made in methods for acidity, ash content, Ramsbottom carbon residue, cold test of motor fuels, Lovibond color, dielectric strength, doctor test, drop point, free acid and alkali in grease, knock rating, oxidation of lubricating oils, oxidation stability of motor fuels, penetration, sludging values, softening point, Reid vapor pressure, and kinematid viscosity. The appendix has been enlarged by the addition of a standard method for evaluating crude oils and a vapor pressure/temperature nomograph for hydrocarbons.

**Some Ideas About Correlation of Test-Engine Results.** T. P. SANDS, C. J. LIVINGSTONE, AND W. A. GRUSE. *Jour. Inst. Petr.* **30** (1944) pp. 68-75.

In the testing of lubricating oil the justification for simplified apparatus arises from the large number of different engine types in use, from the implicit recognition that some common factors in all of them are influencing the way the oil fails, and from the further recognition that small and uncontrolled variations in these fundamental factors will influence the conduct of an oil from one engine type to another. The authors describe the three widely used tests, including (a) the 36-hour Chevrolet test, (b) the General Motors Diesel 500-hour test, and (c) the caterpillar tests including (1) the 480-hour endurance test, (2) the run-in and high-load tests, and (3) the 120-hour test, or hot-box test. The caterpillar 480-hour test can be regarded as not accelerated, the hot-box and scratch test as accelerated, and the Chevrolet and General Motors tests to some extent in the accelerated class. At the outbreak of the war many of the engine laboratories in the country were equipped for these three types of tests

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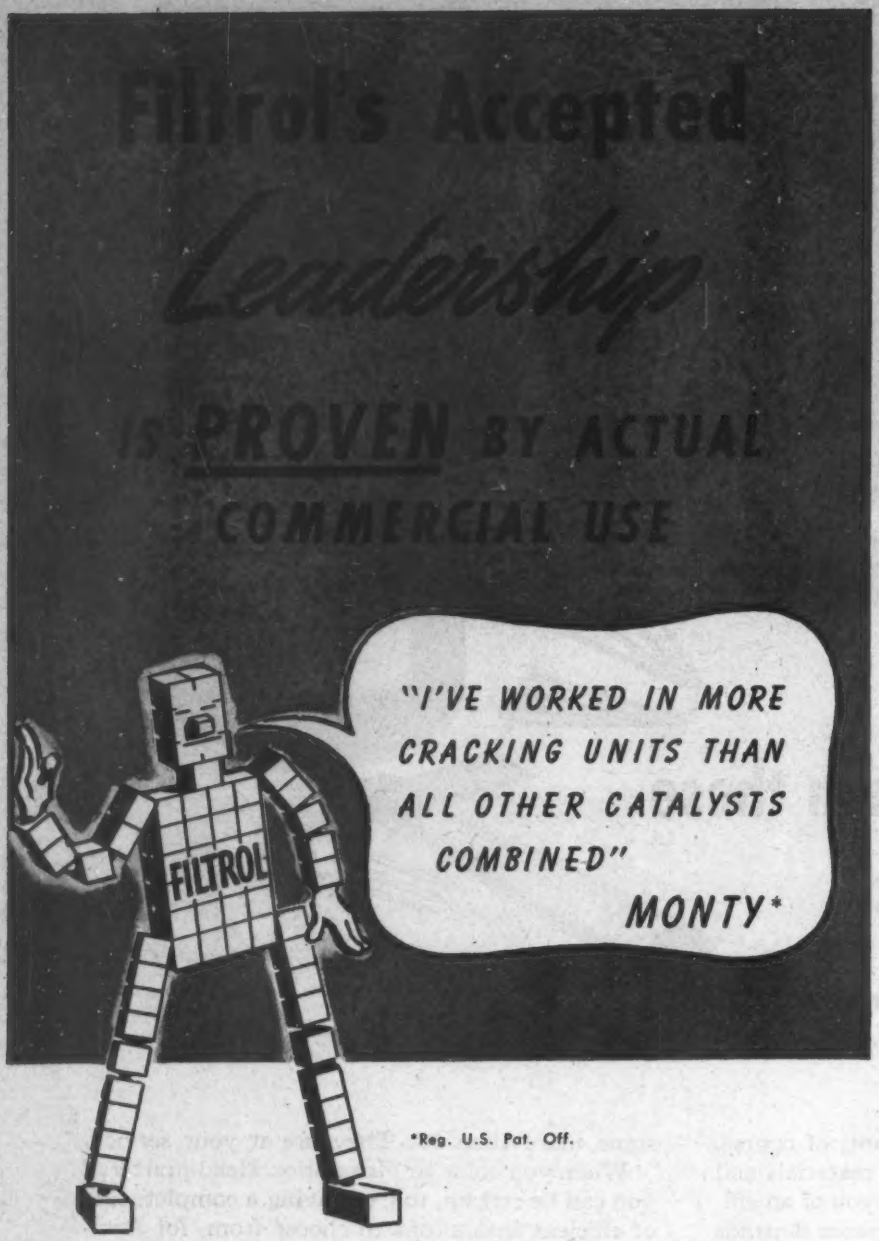


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and a fair degree of success had been attained in developing oils to meet the requirements of each separately. Two or three oils were available that met fairly well the requirements of all the tests. The war effected an immediate consolidation of requirements. The 2-104A specification was written to define a class of lubricants that could meet all the conditions of the three outstanding tests. It was believed by those who took this step that an oil that would meet the requirements of this specification would lubricate satisfactorily all the automotive equipment of the armed forces under the most exhaustive conditions they were likely to encounter. The experience to date has indicated that this judgment was correct. The fact that the armed forces have not experienced any particular trouble to date does not necessarily mean that the tests mentioned actually do correlate with military service demands. It means that we now have oils that are satisfactory under all the conditions, but we do not know how far the mark may have been overshot. The authors feel that it seems a not unreasonable hope that a satisfactory prototype engine can be developed that will be flexible enough to permit operating under such conditions that a reproducible severe condition of varnishing tendency or of bearing corrosion or of wear could be determined in tests. The mode of operation would then be to rate oils in this engine as to detergency, oxidation stability, or wear on numerical scales. Engine tests should be divisible between those that are acceptance tests and those that are accelerated for gaining information. The authors feel that acceptance tests should not be accelerated.

**Safety Cap for Laboratory Glass Distillation Equipment.** G. A. RADER. *Ind. & Eng. Chem.*, Anal. Ed. **16** (1944) p. 276.

A common cause of damaging fires in petroleum laboratories is the accidental increase of pressure in distillation flasks. Such flasks are usually equipped with two stems or necks, one used as the filling opening and the other for a thermometer. Both openings are customarily closed with a cork. During distillation the reflux column or condenser may become plugged, there may be a sudden formation of foam, or the operator may neglect to open a vent line, thereby causing an increase of pressure in the flask. When this occurs the cork may be forced out, releasing a volume of flammable vapor and causing a fire. A safety device has been developed to prevent such fires. One device is attached to each stem and acts as a safety valve by permitting the cork to lift slightly to release the flask pressure, and then to reseat itself. The total amount of vapor released is generally so small that serious consequences are not likely to follow. Sketches are given showing the construction of the device.

**Anomalous Viscosity Shown in Oil Flow Through Engine Bearings.** S. M. NEALE. *Phil. Mag.* **34** (1943) pp. 577-88.

Shearing stress and velocity gradient are usually assumed to be proportional but the author shows that this assumption is not sufficient to explain recent data on oil flow through engine bearings, particularly those of automobile engines. Such bearings can be considered as a viscometer. The

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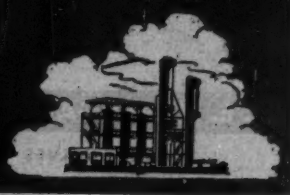

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apparent viscosity of the oil decreases under shear to a small fraction of its normal value. The amount of axial flow is greater than that predicted and the author suggests that this is caused by orientation of oil molecules under shear. Such orientation is parallel to the direction of rotation of the shaft, while the measured flow is perpendicular to this. The effect of rise in temperature is considered, and it is proved that this will not account for the observed decrease in viscosity. Mechanical sources of error are considered and discarded. However, if the reduction in viscosity that is observed is caused by shear along, then the mathematical theory of lubrication will necessarily be modified. Capillary-flow experiments were made with driving pressures up to 150 kg./sq. cm. Castor oil and Mobiloil BB were used. The apparent viscosity fell to one-half the normal value. The boundary layers of the emerging jet of oil were shown to exhibit strong double refraction. This is evidence of the existence of molecular distortion or orientation caused by shear.

**Nomographic Chart for Correcting Weights to Vacuum.** H. C. THACHER, JR. *Ind. & Eng. Chem.*, Anal. Ed. **16** (1944) p. 275.

Although the correction of weights in air to weights in vacuum is a common operation in many fields of precise work, the use of the tables available in handbooks is rather cumbersome when the correction must be applied frequently. Moreover, in many instances greater precision may be required than is obtainable by using tables based on constant air density. The correction factor, K, by which the air weight of an object must be multiplied to give its weight in vacuum is a function of the density of the object, the density of the weights used, and the density of the air. The density of the air, in turn, is a function of the

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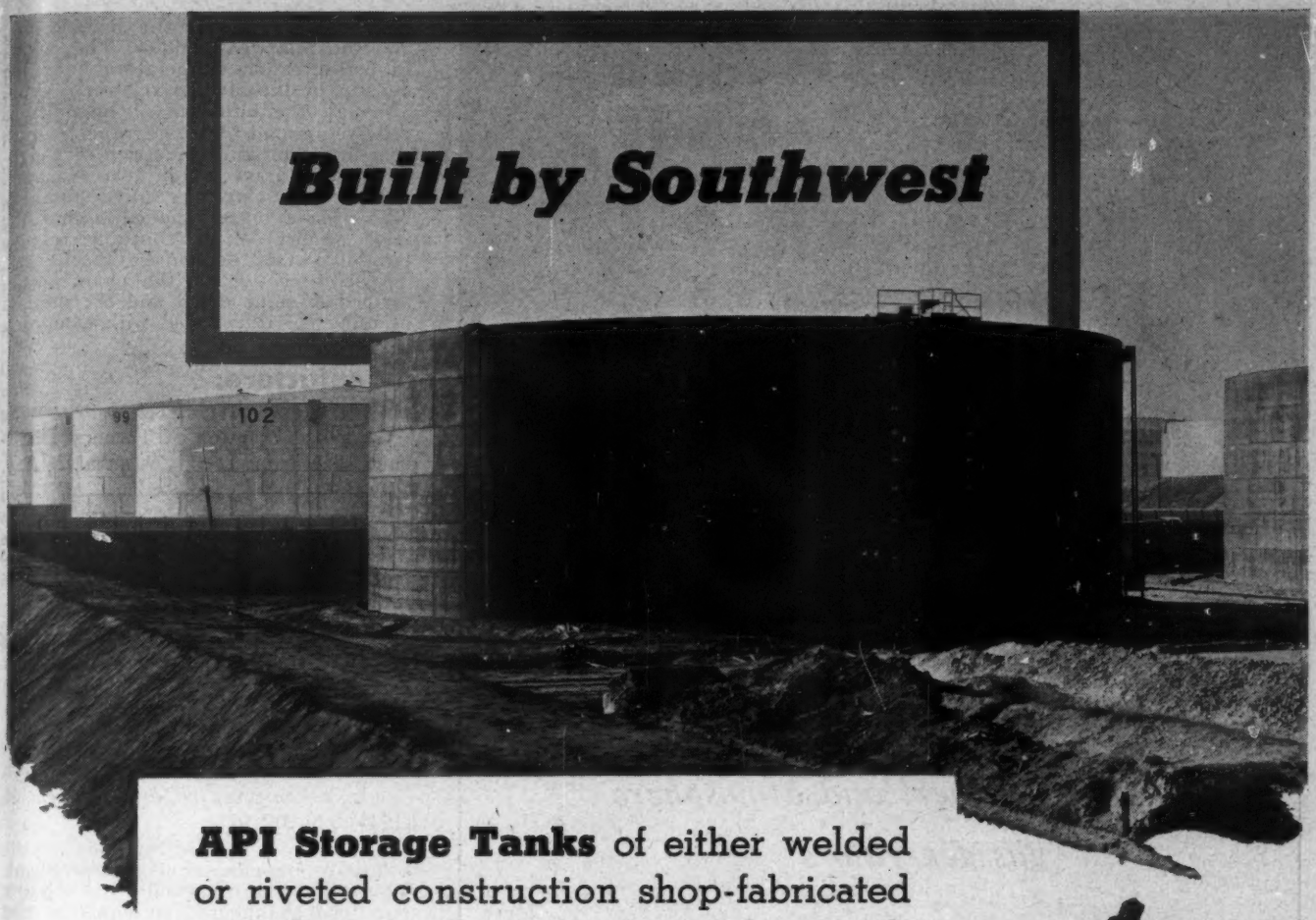

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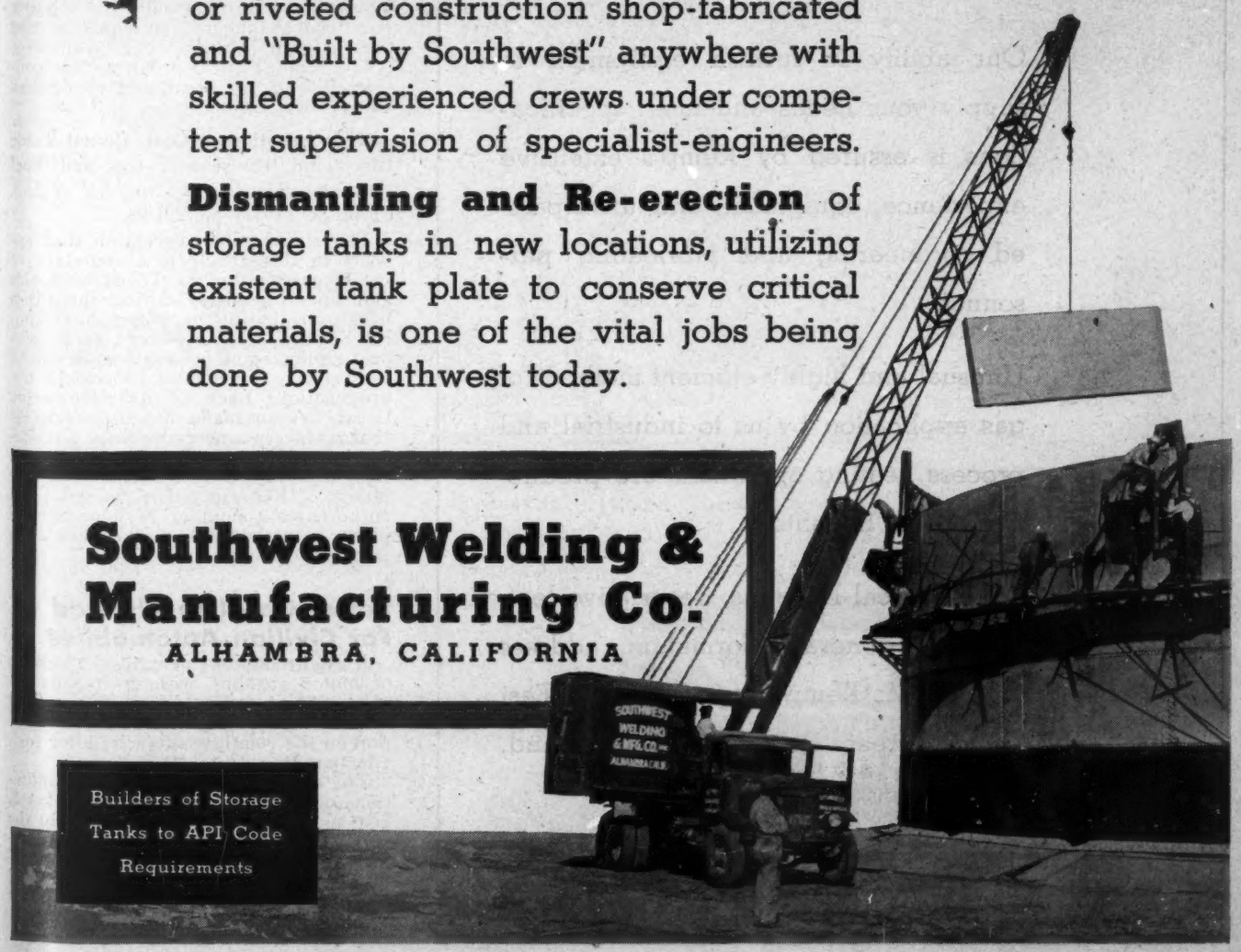


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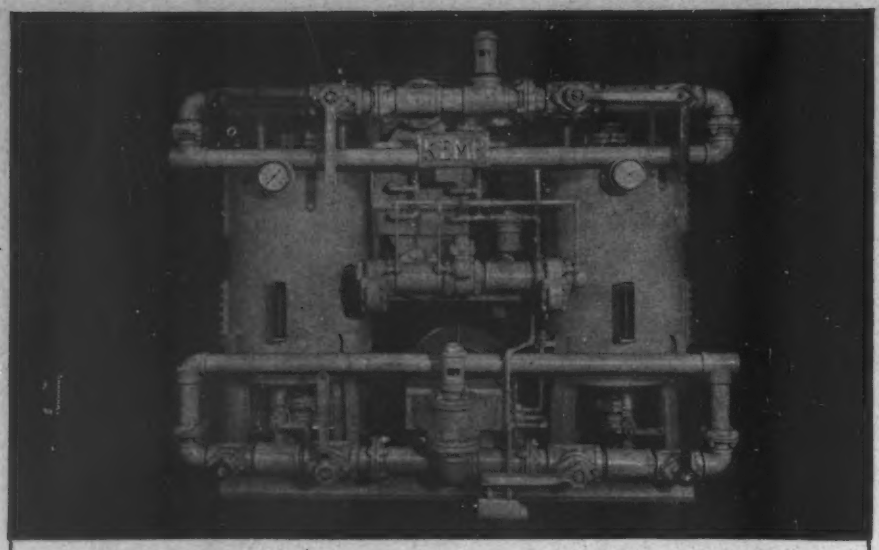

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Barometric pressure, the temperature, and the relative humidity. The effects of pressure and temperature upon the density of the air are relatively great, although the influence of humidity is relatively small. A nomograph is given that facilitates the correction of weighings with brass weights to vacuum. All variables except relative humidity of air have been included within the limits indicated. A constant relative humidity of 50 percent has been used. The construction of the chart is described in some detail and the method of using it is illustrated with examples.

## Manufacture: Processes and Plant

**Graphical Solution of Ternary Distillation Problems.** L. H. Corn. *Ind. & Eng. Chem.* **36** (1944) pp. 378-80.

A new method of plotting ternary distillation data is presented that leads to a graphical solution. The procedure outlined illustrates the representation of the ternary system from the three limiting binary systems, and shows how such a representation eliminates trial-and-error calculations of the equilibrium relationships. The procedure is illustrated by use of the system benzene-toluene-xylene at atmospheric pressure.

**Designing Condensers.** R. E. Peck and L. A. Bromley. *Ind. & Eng. Chem.* **36** (1944) pp. 312-16.

The authors present methods for the solution of condenser design problems. To avoid a long trial and error solution they use a fundamental equation and present their solution in the form of a nomograph. Typical problems are considered, both for horizontal condensers and vertical condensers.

**Hydrogenation of Coal.** Round Table Discussion, Division of Gas and Fuel Chemistry, Amer. Chem. Soc. *Ind. & Eng. Chem.* **36** (1944) pp. 291-98.

The round table discussion that appears in this article is a summary of the discussion by the Division of Gas and Fuel Chemistry during the Pittsburgh meeting of the American Chemical Society. It is presented as a compact summary of present knowledge of the primary liquefaction of coal by hydrogenation. Lack of petroleum in Great Britain made the utilization of coal resources a necessity long ago. Recently public opinion was aroused in this country to the extent that the House of Representatives passed a bill authorizing a number of experimental plants to make synthetic gasoline from coal and other products.

## Better Gasoline Allowed For Civilian Automobiles

A slight improvement in the quality of motor gasoline without impairment of supplies for military use is provided for in an order revoking PAW limitation on the volatility of such motor fuel, effective May 22.

The order merely removes the limitations on volatility imposed November 8, last, as a result of improvement in the supply of components, but does not affect any other orders on maximum octane number—76 for premium and 72 for house brand gasoline—and will not affect the maximum production of aviation and military gasolines.

# On its Way for Duty

This auxiliary air heater presented a more-difficult-than-usual fabricating job, being a highly complicated design. Standard Steel engineers and craftsmen completed construction in record time and it is shown here on its way for duty in a refinery producing 100-octane gasoline. Here it will heat compressed air up to temperatures approximating 1000° F., or greater as needed to increase the activity of the chemical agents used in catalytic cracking.

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Taylor Instrument Companies, Box 110, Rochester 1, New York, has announced a new 4½-inch Phenolic case dial thermometer, a mercury actuated instrument designed to withstand severe operating conditions. It is described as particularly well suited to installations requiring a long length of tubing between the bulb and the instrument.

The plastic case is resistant to corrosion and shock. To make reading at a distance easy the metal dial is finished in black with white figures.

This thermometer can be had with a wide variety of standard temperature-sensitive bulb constructions and is available in the following ranges: —40° F. to 120° F., 40° F. to 220° F., 350° F. to 550° F., 400° F. to 900° F., —10° F. to 110° F., 80° F. to 300° F., 300° F. to 750° F., 30° F. to 150° F., 50° F. to 400° F., 200° F. to 900° F.

## Rod Holder

Martin Wells, 5886 Compton Avenue, Los Angeles 1, has developed a rod holder with a reinforced snap-on insular cap, for holding welding electrodes.

The insulator cap is made of heavy plastic with reinforced jacket. It is notched on the inside so that it slips over the vise body and is held securely in place by a steel spring. Insulators can be easily and quickly replaced on the job by breaking the damaged insulator with a chipping hammer and snapping a new one into place.

The vise body provides a positive grip, up to 1000 pounds pressure per square inch that prevents dropping rods.

The rod hole in the rod saver is set at a 60-degree angle, providing maximum flexibility and ease in reaching inaccessible and tight corners. The hole accommodates through 5/16-inch rods.

## Welding Supplies

Air Reduction Sales Company, 60 East 42nd Street, New York 17, has published a revised catalog and price list of gas- and electric-welding supplies and accessories.

Products include gas-welding rods in a wide range of metals, types and sizes for all welding requirements. Also included is detailed information of assistance to buyers, such as: sizes, dimensions, weights, stock numbers, forwarding data and recommended uses for products.

Among the new items described are the Airco No. 66 welding helmet which is leakproof. The headgear is adjustable to headsize and is of the sliding type, with two positive stop joints that keep it centrally located.

Another new item is the Suregrip Rod Saver that effects savings in electrode cost because only 5/8-inch of the bare electrode can be inserted in the socket, thus eliminating wasteful overhang. The design of the handle with 28 large openings reduces contact with the welders' gloves and minimizes overheating, even when electrodes are burned to a 1-inch stub. Electrodes are firmly gripped by a quarter turn of the handle. The handle is made of insulating material not affected by moisture, or heat.

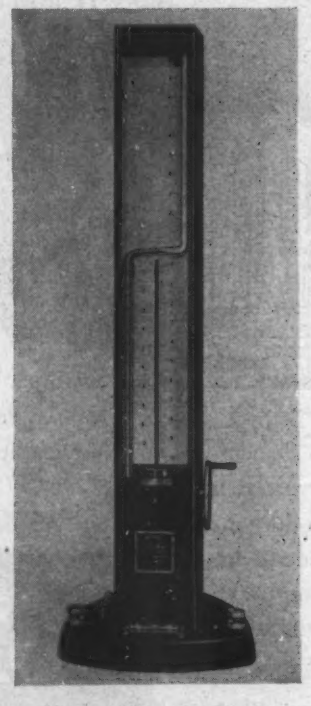
Taylor Dial Thermometer

Also described is the Atlas Model A Dual-Tool for cleaning welds. This is a dual purpose tool that cuts down tool handling time. It consists of a chisel-headed chipping hammer combined with a wire bristle brush. The brush reversing feature doubles its life. All parts are readily replaceable.

## Micromanometer

The Meriam Instrument Company of Cleveland, Ohio, announces a new device for calibrating low-pressure instruments and as a convenient manometer for reading pressures and vacuums.

A highly sensitive instrument, the



Meriam Micromanometer

Meriam Micromanometer permits readings to plus or minus .001-inch water pressure. It is quite different from anything now on the market.

In simplicity of operation it surpasses the hook gauge. It is not the least complicated or mysterious and can be handled successfully by the average operator.

## *Electronic Relay*

A new electronic relay for amplifying the very limited current transmitted by delicate control contacts or high resistance circuits, thus materially increasing the application range of many control devices, has been announced by the Industrial Control Division of the General Electric Company. Operated by any material having a resistance of from 0 to 500,000 ohms, or even greater if necessary, the new relay is especially suitable for controlling liquid levels in tanks and boilers, sorting metallic parts by size, detecting broken threads in textile machines, and as a limit switch requiring extremely light pressure to operate.

Small and light in weight, thus facilitating easy installation, the new relay consists of a standard type electronic tube, a supply transformer, and an electromagnetic relay—all mounted in a totally enclosed, weather-resistant enclosure suitable for wall or machine mounting.

In operation, the electromagnetic relay in the device is kept energized as long as the controls connected to the input grid circuit of the electronic tube remain open. The instant these contacts close, the relay is de-energized. A built-in time delay feature prevents chattering when the contacts in the input circuit are momentarily closed. A contact arrangement on the electromagnetic relay permits the device to be used either to make or break a load circuit when the actuating contacts connected to the input circuit on the electronic relay are closed.

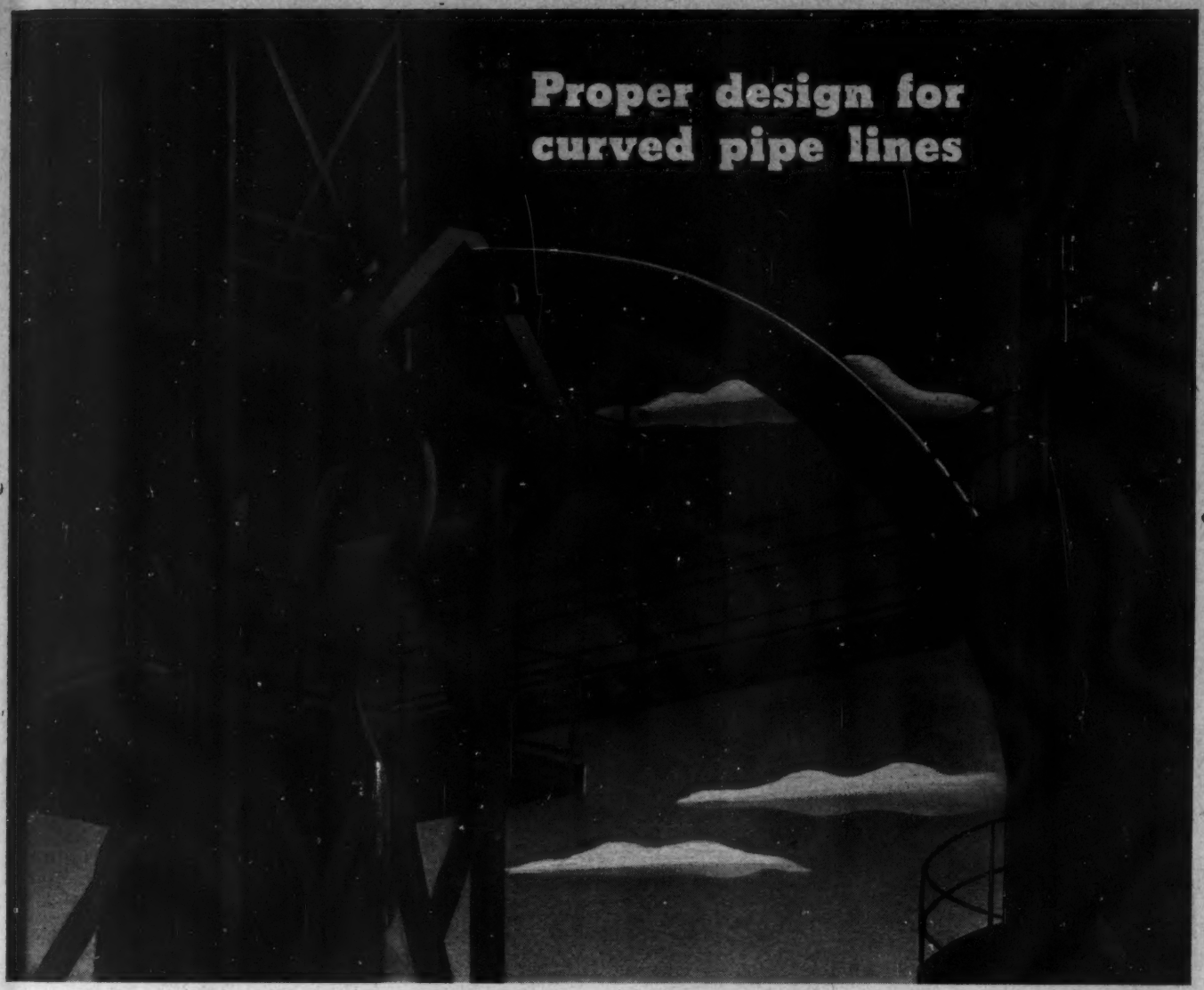
## *Gas Analyser*

Cambridge Instrument Company, 3732 Grand Central Terminal, New York, has developed a four-point gas analyser which provides simultaneous analysis and continuous graphic record of the amounts of oxygen, carbon dioxide, carbon monoxide and hydrogen in a sample of combustion products. Chemicals, fragile glassware and moving parts in the analyses unit are eliminated. The instrument is useful in processes where knowledge of the amounts of the gases mentioned is required. Its use enables close control in chemical processes, oil refining and in the operation of various types of kilns, inert gas producers, furnaces in the metallurgical industry and other combustion processes.

The complete analyser operates directly from the alternating current supply line. The recorder may be located at any required distance from the sampling point and the instrument can be furnished with contacts for operating warning signals or to actuate various control circuits.

In theory the instrument accomplishes analysis by direct comparison of thermal-conductivity of the sample with that of a reference gas or by comparison of thermal-conductivity of the sample before and after chemical absorption or combustion.

This principle of operation permits units to be assembled to meet many special problems. In the operation of a typical unit a continuous sample of the




*Information supplied by "Petroleum Refiner"*

Calculations that go into designing a self-supporting arch of pipe between two refinery vessels can be interpreted in steel conservation. Connecting the vessels with horizontal piping is simple but it calls for a support of structural steel, since the piping must provide for expansion and contraction incidental to the temperature changes in liquids that pass from vessel to vessel.

As an arch with a tie rod the piping may be made to support itself and thus eliminate the supporting material.

But the design is more intricate than the simple proposition of bending a piece of pipe and welding it in place. The engineer must know the pull on the tie rod in pounds, the spring in the arch in inches, the modulus of elasticity, the coefficient linear expansion and a few other essentials.

With the proper background and accurate calculations he can erect the arch, save the supporting steel and leave the ground space free below. The casual observer looks upon the arch as something neat, but the engineering approach is that some steel was saved.

CLIMAX FURNISHES AUTHORITATIVE ENGINEERING DATA ON MOLYBDENUM APPLICATIONS.

ARMY E NAVY

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**Climax Molybdenum Company**

**500 Fifth Avenue · New York City**

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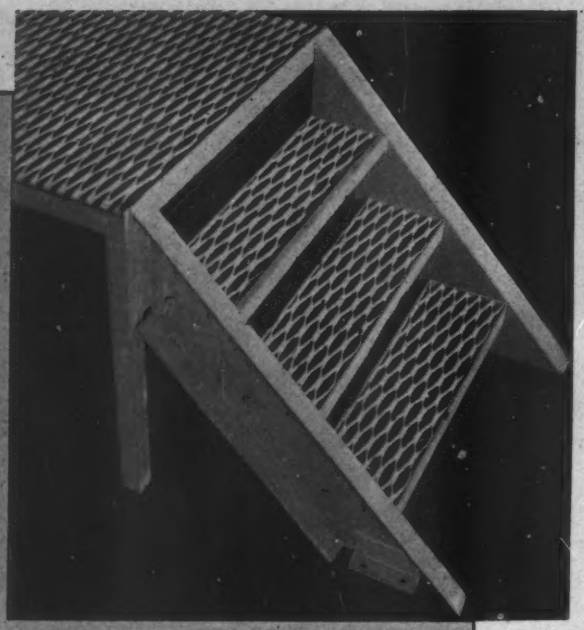
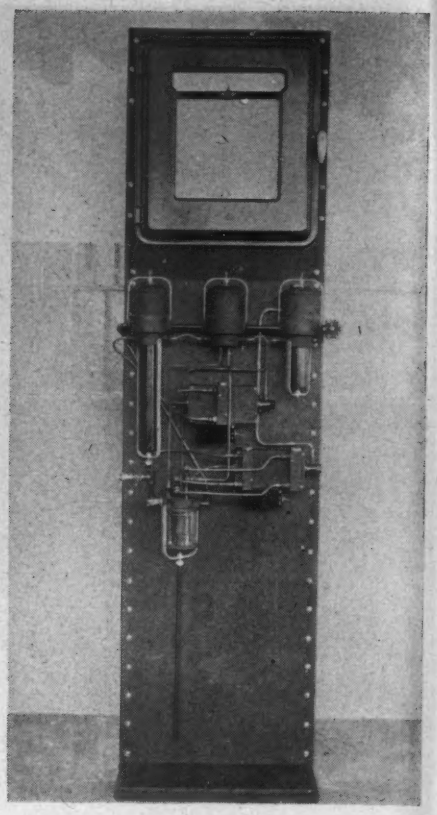


**THE CONSOLIDATED EXPANDED METAL CO'S**

**WHEELING, WEST VIRGINIA**

*Offices in Principal Cities • It's Wheeling Steel!*



**Cambridge Gas Analyser**

gas is drawn into the analyser by means of a water bubbler-aspirator. The exact detail of the analysis procedure varies with the constituents of the sample but may involve a chemical absorption and/or combustion. The aspirator not only draws in the sample gas but meters it, as well as the air which may be required for combustion in the analysis procedure.

In all applications the results are recorded directly without any corrections or interpolation of any kind. The upkeep required is of a routine nature and does not require the services of a technically trained man.

The recorder is automatically connected to the circuit of each analysis cell in succession, the duration of each connection being one minute. There is no additional time lag between points because the gas sample flows continuously through all cells.

A continuous record of the analysis is provided on a strip chart, and the four different registrations (one for each gas) are shown by different colors and numbers on the chart.

## Tube Expander-Driver

Invincible Tool Company, Empire Building, Pittsburgh 22, Pennsylvania, has developed an angle tool attachment known as the Invincible Boiler Tube Expander-Driver. This new tool, states the manufacturer, provides the link between the tube expander and the driving unit, making it easy to get at "hard-to-reach" spots. These expander-drivers work in right- or left-hand corners. They are made in two standard sizes with ¾- and ½-inch square driving chuck. A special ball thrust take-up takes the thrust both forward and reverse. All thrust action is taken directly

**Design and estimating by competent engineers who recommend the materials best suited to the type of service for which the work is intended . . .**

**Sensible methods of manufacture in completely equipped shops . . . Prices in line with built-in Downingtown quality.**

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Helping producers to deliver fighting fuel is SOLVAY LIQUID CAUSTIC POTASH, supplied from SOLVAY'S new potash plant to meet your requirements. As America's largest producer of Soda Ash, Caustic Soda, and other important alkailes, SOLVAY has developed both men and facilities to produce Caustic Potash of a high quality and with an *absolute minimum of impurities.*

★ Solvay Caustic Potash Liquor (shipped in tank cars)—has KOH content of approximately 50%.

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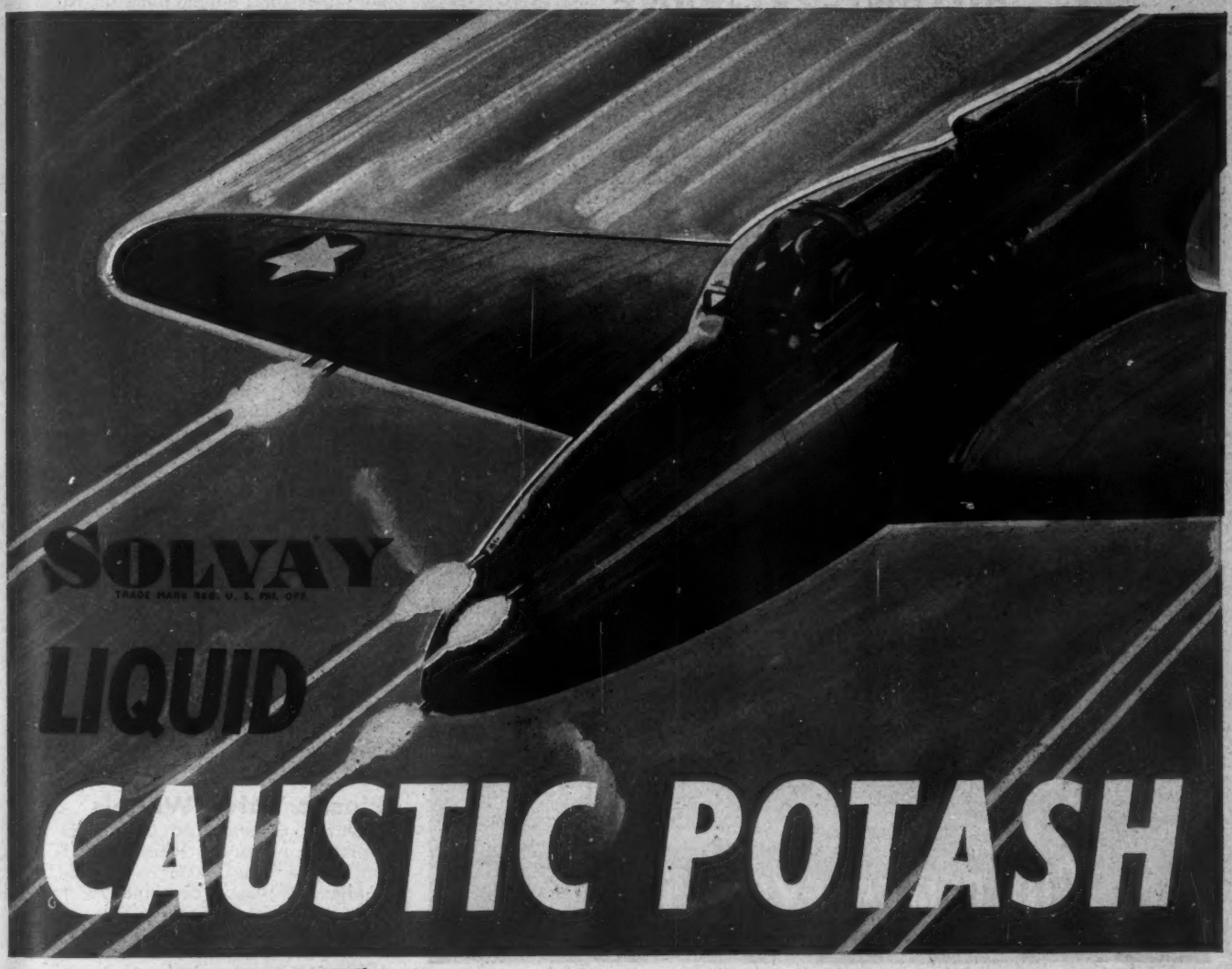


★ LIQUOR
(45-50% KOH)
Shipped in tank cars—
10,000 gallons.

★ SOLID
(90% minimum KOH)
Shipped in steel drums—
700 lbs.

★ FLAKE
(90% minimum KOH)
Shipped in steel drums—
350 lbs.

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so he's using an

Ampco Non-Sparking Safety Bung Wrench

This all-purpose bung wrench is typical of more than 400 standard tools described in the Ampco Safety Tool Catalog. Wherever a spark may ignite explosive fumes, gases, or dust—endangering men at work and a fortune in plant equipment—it pays to provide this protection. Tested and approved by Factory Mutual Laboratories and other insurance authorities, frequently required to earn lowest insurance rates. Widely used in oil refining, chemical manufacturing, ordnance plants—in mines and on ships at sea. • Standardize on Ampco Safety Tools.

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on these bearings, allowing instant reversal of driving direction. These tools are ruggedly built for heavy-duty service, can be used to run on or off nuts, studs and bolts in tight spaces, and are obtainable in square or hexagon spindles and square, hexagon or Morse taper shanks. Special models can be designed to meet individual requirements.

## Insulation Coupling

The Ric-WiL Company, 1572 Union Commerce Building, Cleveland, Ohio, has announced a drive coupler which simplifies final connections on Ric-WiL prefabricated insulated pipe conduit. The insulated conduit is shipped in convenient 21-foot sections — completely prefabricated with pipe or pipes, insulation and aligning pipe supports. Ends of helical corrugated conduit are expanded smooth at the factory, removing corrugations for a distance of 3 inches. Bare pipe extends beyond ends of conduit for 3 more inches. After pipe has been coupled or welded, and insulation applied over exposed portions, smoothed ends of conduit are coated with waterproof sealing cement. A heavy-gauge split connector sleeve is then slipped over the opening and clamps are driven onto wedge-shaped channels over the lapped joint. Where a welded closure is required, cement is omitted and ends of sleeve lap-welded to conduit after clamps have been applied. Clamps are then removed and longitudinal seam lap welded. For extra strength, clamps may again be driven onto channels after weld is made.

When conduit coupling is completed, an asphalt blanket, applied with heat over the entire closure area, fuses with factory applied asphalt, assuring uniform protection at all points.

Accessories for the complete system — including expansion loops, elbows, tees, anchors, reducers, etc., are prefabricated and equipped with the same drive coupler for assembly with conduit sections. The conduit is adaptable to underground, surface, or overhead installations.

## Plastic Valve Wheels

Durez Plastics & Chemicals, Inc., North Tonawanda, New York, is making valve hand wheels molded from a phenolic plastic combined with wood pulp.

The material is impervious to the effects of oils, and many chemicals. It has great impact strength and exceptional resistance to water, acids, and alkalies, and low heat conductivity.

## Generator

Century Electric Company, 1806 Pine Street, St. Louis, Missouri, now has alternating current generators available in sizes from ½ to 150 K. V. A. for direct connection or belted drives.

In the direct-connection type, the revolving field generator is arranged to bolt directly to the engine housing and the generator shaft is machined to receive a flange that bolts directly to the engine shaft. This generator has one bearing, with the engine end of the shaft supported by the engine bearing. The exciter is mounted on the end of the generator opposite the engine. The exciter shaft is inserted in and keyed to the generator shaft on the inner end and the generator bearing carries the exciter.

# ISO-FLOW* TUBULAR FURNACES

FOR

VAPOR SUPERHEATING

CHEMICAL REACTIONS

CHEMICAL CONCENTRATION

REBOILERS

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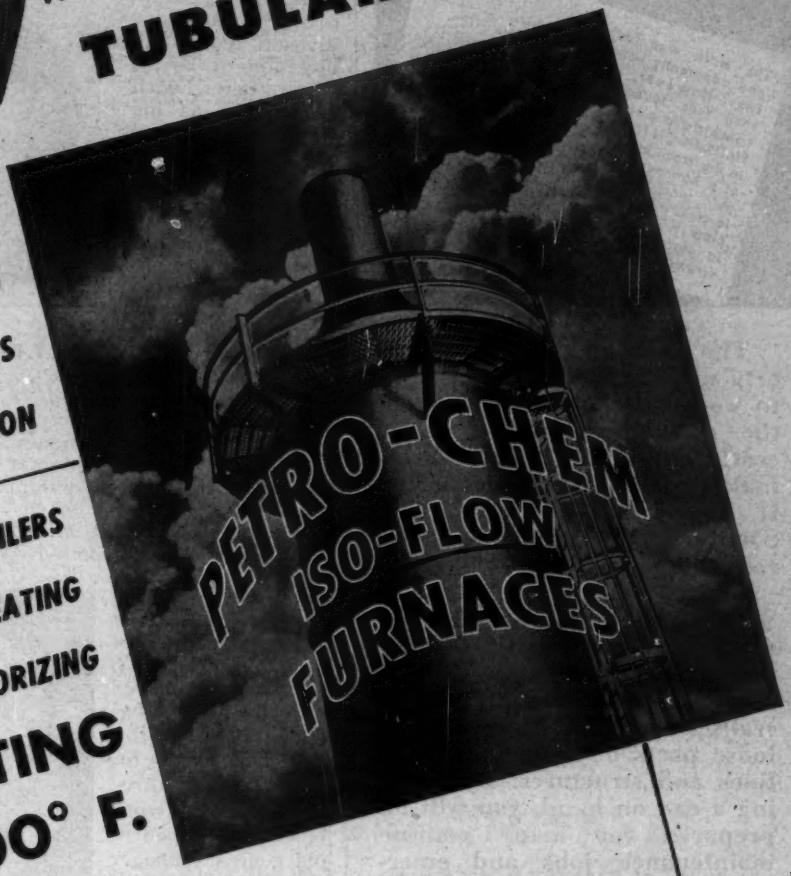


## DESIGNED FOR HEATING FLUIDS UP TO 1600° F.

**SAVE CRITICAL MATERIALS**

PETRO-CHEM ISO-FLOW* FURNACES save 30 to 50% in critical materials, eliminate furnace maintenance and fulfill all process requirements, efficiencies and mechanical standards. They require less than half the overall steel — 50% less alloys — 35% less headers—30% less furnace tubes —50% less refractories—40% less foundations — no independent stack and 75% less ground space.

Investigate this direct-fired tubular furnace. The economics of the ISO-FLOW* Tubular Furnace, for low or high temperature operations, are of such magnitude that they justify your investigation.

*Trade Mark. Patents issued and pending.

**PETRO-CHEM DEVELOPMENT CO., INC., 120 EAST 41st STREET, NEW YORK, N. Y.**

Representatives: Bethlehem Supply Co., *Tulsa, Houston, Los Angeles* Faville-Levally Corp., *Chicago.*

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REPAIR
RECORDS
Cracked Heater Shell
The crack was long and apparently hopeless. However, the shell was saved by tamping a putty of SMOOTH-ON No. 1 into the crack by means of a hammer. The repair was then reinforced with a patch plate which was held in place by machine screws.
SMOOTH-ON
Reinforcing patch plates for SMOOTH-ON repairs need not be in one piece, and frequently narrow straps or bands will serve the purpose.
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**For half a century, SMOOTH-ON has been demonstrating these qualities which have made it a necessity in every plant for stopping leaks, sealing cracks, and tightening loose parts of apparatus, pipe lines and structures. By keeping a can on hand, you will be prepared for many routine maintenance jobs and emergency repairs.**

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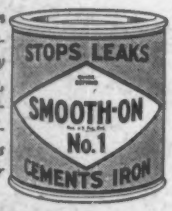

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# ☆ BUSINESS NOTES ☆

**Allis-Chalmers Manufacturing Company,** Milwaukee, has organized a research and gas-turbine development division under the direction of Dr. J. T. Rettalita, with J. L. Ray as his chief engineer and assistant. Dr. Rettalita's work, which has been largely in the development of the gas turbine, has earned for him annual awards from national engineering and scientific societies for the past three years. Many engineering groups have been hearing his interpretations of gas-turbine devolepment and significance. He received his degree of doctor of engineering at Johns Hopkins University in 1936.

J. T. Rettalita

**Worthington Pump and Machinery Corporation** has appointed Walter D. Smith of Tulsa, commercial vice president. A graduate of Carnegie Institute of Technology, Smith has been connected with the Worthington organization since 1923, except for a period of three years, 1933-36, when he was vice president and general manager of American Natural Gas Company of Shamrock, Texas. For the past four years he has been manager of the Tulsa district office, as well as Southwestern manager of the engine sales division. In his new capacity he will supervise the corporation's business in the Southwest.

W. D. Smith

**Mixing Equipment Company,** Rochester, New York, announces that James V. Donohoe has been appointed assistant sales manager, with headquarters in Rochester. He was formerly located in the New York office.

**General Controls Company,** Glendale, California, recently occupied new branch office quarters at 687 Boylston Street, Boston 6, Massachusetts, and at 1505 Broadway, Cleveland, Ohio. The Boston branch is under the direction of William Marsh, who has had 20 years' experience in the automatic controls industry. L. E. Wetzel, Cleveland manager, is a graduate of Purdue and John Huntington Institute Technical College where he majored in air conditioning, heating and ventilating engineering. His field experience covers 16 years in the refrigeration and general installation fields.

Wm. Marsh

L. E. Wetzel

**Union Carbide and Carbon Corporation** has announced election of the following presidents of subsidiary companies:

Dr. Joseph G. Davidson has been elected president of Carbide and Carbon Chemicals Corporation, and Carbide and Carbon Chemicals, Ltd. Dr. Davidson holds degrees in chemistry from the University of Southern California and Columbia University. He participated in the early work in synthetic organic chemistry which led to the foundation of Carbide and Carbon Chemicals Corporation, and has served in this company in technical and executive capacities since its formation.

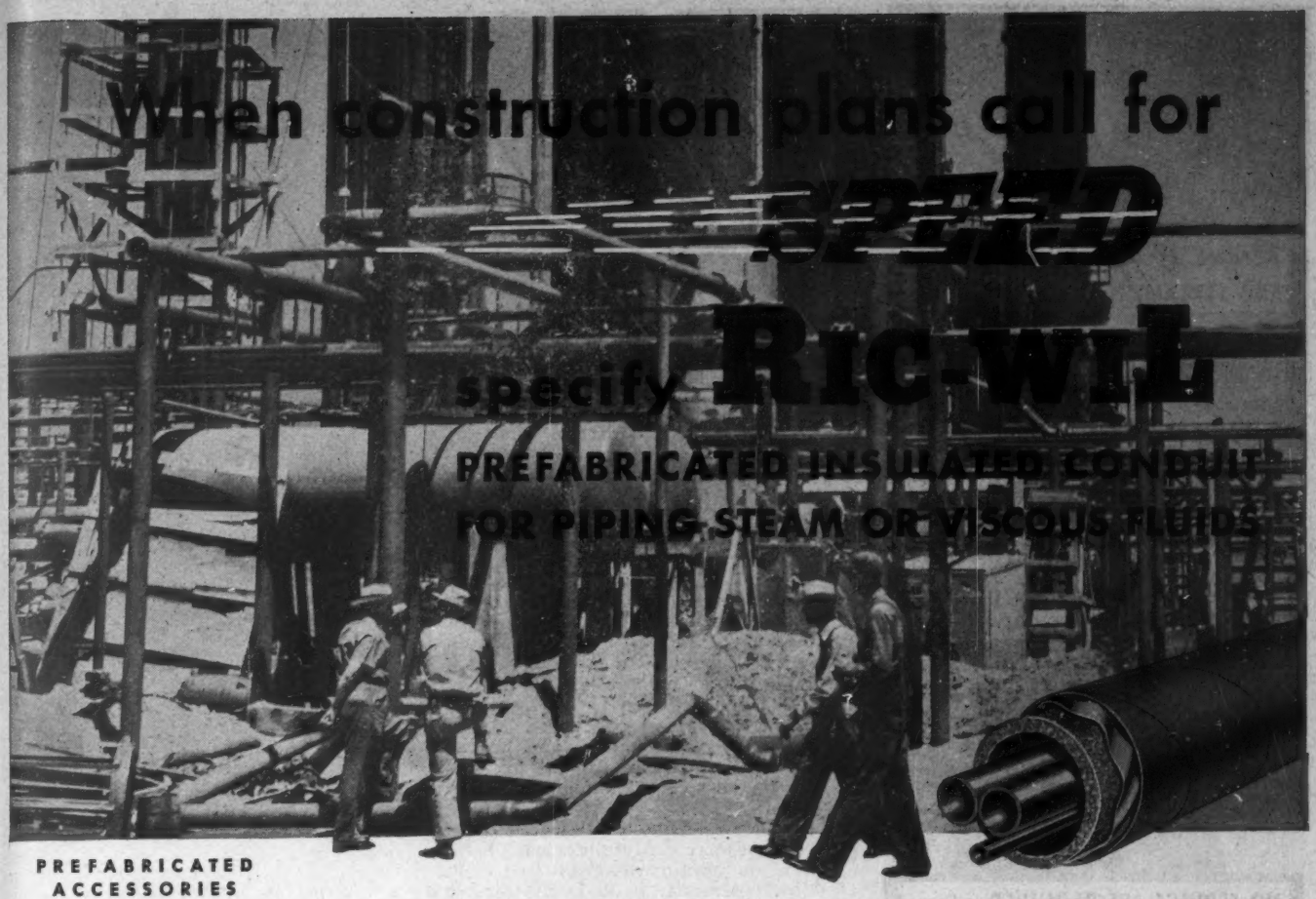
James W. McLaughlin is the new president of the Bakelite Corporation. McLaughlin was granted the degree of Bachelor of Science in Mechanical Engineering by the University of Illinois in 1914. After a short experience as an engineer with Peoples Gas Light and Coke Company in Chicago, he entered the employ of The Prest-O-Lite Company. He has been in charge of major production operations in the industrial gases and chemicals companies of the Corporation continuously since that time. McLaughlin will direct all of the plastics operations of units of the corporation, including the plastics division of Carbide and Carbon Chemicals Corporation.

Stanley B. Kirk becomes president of The Linde Air Products Company, The Prest-O-Lite Company, Inc., Dominion Oxygen Company, Ltd., and Prest-O-Lite Company of Canada, Ltd. Kirk was graduated in 1913 from the University of Wisconsin and entered the employ of Union Carbide Sales Company in 1915. Continuously since that time he has been responsible for sales and sales management in the gas group of companies of the corporation.

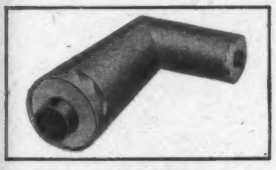
J. G. Davidson

S. B. Kirk

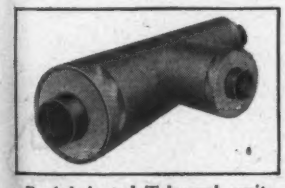
Arthur V. Wilker has been elected president of National Carbon Company, Inc., and Canadian National Carbon Company, Ltd. Wilker holds degrees from Baldwin Wallace College and Case School of Applied Science. After spending a year as head of the department of chemistry at the University of Evansville, he became associated with National Carbon Company in 1910. Continuously since that time, with the exception of three years as




**PREFABRICATED ACCESSORIES** *ready to install*



*Prefabricated elbow unit*



*Prefabricated T-branch unit*

*Prefabricated anchor unit*

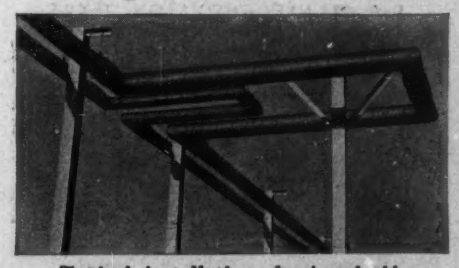
*Prefabricated gland seal*

## FACTORY PREFABRICATION SAVES TIME AND MONEY ON THE JOB

Every contractor knows the loss of time, the hazards and the cost of sundry materials needed for insulating, waterproofing, wrapping and wiring of overhead pipe lines, when this operation has to be done on scaffolding. He also knows the amount of excavation and skilled labor required to apply insulation and protection on underground lines. The Ric-wiL Unit Method of installation eliminates most of this field work and makes possible phenomenal speed on the job. Prefabricated 21-foot sections are delivered to job site—complete with pipe, insulation, couplings and accessories—ready for hoisting onto trusses or lowering into narrow trenches. Often a number of units are welded and coupled on the ground before installation, minimizing overhead and trench work under difficult conditions. On one job, 1500 feet of Ric-wiL Conduit were installed in place on channel steel uprights, and pipe welded, ready for couplers and insulation between units—*in only two working days* . . . Ric-wiL Insulated Pipe Units are available in single or multiple pipe systems, for piping steam, hot water, oil or viscous fluids where flow temperature must be maintained.

### *PREFABRICATED EXPANSION LOOPS*

Completely assembled expansion units are provided as required, fitted with couplers, ready for quick installation. Adaptable to underground, surface, and overhead systems.

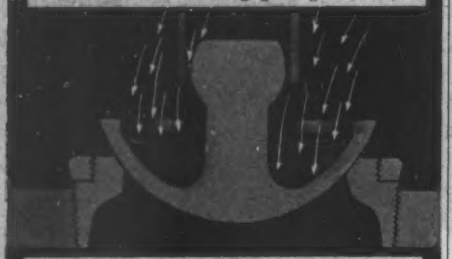


*Typical installation showing double overhead expansion loop for steam and return line.*

**RIC-WIL** INSULATED PIPE CONDUIT SYSTEMS
THE RIC-WIL COMPANY · CLEVELAND, OHIO
AGENTS IN PRINCIPAL CITIES

*Royal Crown* PUMP VALVES ARE STREAMLINED TO THE FLOW

THEY ROTATE, SWING, AND SEAT at the will of varying side pressures from the fluid being pumped.



NO SPRINGS ARE REQUIRED to force the valve to seat—the cup-like top of the valve makes it close instantly.

R C VALVES ARE AVAILABLE in all sizes, all metals. Valve and seat are factory ground and lapped together.

**MADSEN IRON WORKS**
HUNTINGTON PARK, CALIFORNIA

*Distributors:*
L. B. STANLEY—HOUSTON, TEXAS
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*Royal Crown*
PUMP VALVES

A. V. Wilker

F. P. Gormely

head of the department of chemistry at Baldwin Wallace College, of which at present he is a trustee, he has been responsible for production and important research work in the manufacture and use of carbon and graphite products.

Francis P. Gormely has been elected president of Electro Metallurgical Company, Electro Metallurgical Company of Canada, Ltd., Haynes Stellite Company, Michigan Northern Power Company, and Union Carbide Company of Canada, Ltd. Gormely was graduated from the University of Michigan with a degree in electrical engineering in 1909. He immediately joined Union Carbide Company at Sault Ste. Marie, Michigan, as an electrician, and he has served continuously in various production and executive capacities since that time.

John D. Swain has been elected President of Electro Metallurgical Sales Corporation. Swain was graduated from DePauw University in 1912. His service with corporation units began in 1915 when he joined Union Carbide Sales Company at Chicago. He served in the Army Air Corps in World War I, resuming his sales work at the end of the war. Since that time he has served continuously in sales executive and administrative capacities.

John R. Van Fleet becomes president of United States Vanadium Corporation. Van Fleet has been identified with the natural resource supplies of the corporation for many years. This work has involved world-wide investigations as well as the direction of development and research work which led to the production of adequate American supplies of war-necessary vanadium and tungsten, and other alloy metals. Van Fleet is also president of Union Mines Development Corporation.

**Dresser Manufacturing Company** has announced election of J. B. O'Connor as executive vice president, and Arthur R. Weis and Lyle C. Harvey as vice presidents.

J. B. O'Connor

O'Connor has been a director of the company since 1938. He is also vice president and general sales manager of Clark Brothers; chairman of the board of the Pacific Pump Works; and president of Bovaird and Seyfang, all subsidiaries of Dresser Manufacturing Company.

O'Connor attended the University of Georgia and served in the United States Army in the first World War. In 1919, he joined Prairie Oil & Gas Company,


**A view of one of many plants designed and constructed by Petroleum Engineering, Inc., in the past 15 years of continuous service to the industry. *Petroleum Engineering, Inc. Offices: Tulsa and Houston.***

Photographed for Petroleum Engineering, Inc.
By Robert Yarnall Richie

# WINNERS

## MUST HAVE QUALITY . . . AND ENDURANCE

Maybe you didn't have your money on the winner in the 70th Kentucky Derby! Maybe you couldn't pick a horse like Pensive from a field of 16 starters. But one thing you did know—and have always known—is that it takes quality and endurance to win in any race.

In buying your postwar Water System, you had better remember the quality-endurance formula. You can't afford to own an "also ran" water system when the days of war are over and peace is here again.

You can put your money square on the "nose" of a Layne Water System — and always win. You will win on quality and endurance. You will get large quantities of water at low cost. You will get dependable performance year in and year out. And you will get a mighty big reward in knowing that you own the world's finest and most efficient Water System.

Right now is a good time to make preliminary plans. You can secure the aid of Layne Engineers without obligation. You can get set for the days of peace. Late literature will be helpful. Address Layne & Bowler, Inc., General Offices, Memphis 8, Tennessee.

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BUILDERS OF WELL WATER SYSTEMS FOR INDUSTRIES AND MUNICIPALITIES


and in 1923 became sales manager of the Socony Vacuum Oil Company. He joined Clark Brothers in 1927 as general sales manager and became a vice president in 1935. He is also a director of the Gulf Plains Corporation of Corpus Christi, Texas.

Weis is president of the Pacific Pump Works, Huntington Park, California, a Dresser subsidiary.

Harvey is president of the Bryant Heater Company of Cleveland, also a subsidiary.

**General American Process Equipment Division of General** American Transportation Corporation, 420 Lexington Avenue, New York, announces appointment of Dr. C. L. Knowles as technical director. For the past 20 years he has been sales engineer and manager of the Eastern sales division of The Dorr Company, and is vice president of the Chemists Club and director of the American Institute of Chemical Engineers.

C. L. Knowles

**National Tube Company** has converted its Houston sales office into an independent district office, and Forrest A. Marsh, who has been division sales manager since 1936, has been appointed district sales manager. Prior to the conversion, the Houston sales office operated under the Dallas district. Marsh entered a student training course at National Tube Company's plant at Gary, Indiana in 1924, after attending Purdue University. He progressed through the chemical and metallurgical department to production engineering and field engineering department. He worked in Pittsburgh and Tulsa before going to Houston in 1933.

F. A. Marsh

**The Wm. Powell Company,** Cincinnati, announces reelection of its officers, H. H. Coombe, chairman and treasurer, James Coombe, president and general manager, G. E. Weitkamp, vice president and secretary, and David Forker, Oliver F. Gang, Wm. Heilig, and Elmer R. Noll, vice presidents. New vice presidents named include Wm. R. Kraus, Wm. E. Minor, Harry C. Morine, E. K. Pierce and E. W. Voss, and Wilton Husing was made assistant to the president.

**The Bristol Company,** Waterbury 91, Connecticut, has opened a branch sales office in the Engineer's Building, Cleveland 14, Ohio, with G. H. Gaites located there as regional sales supervisor of the Cleveland and Pittsburgh territories. Gaites was transferred from Pittsburgh where he has been succeeded as district manager by H. C. Clarke. Gaites has been with the company since 1920 and for two years, 1935-37, was stationed in England, returning to become manager at Pittsburgh in 1937. Clarke has been


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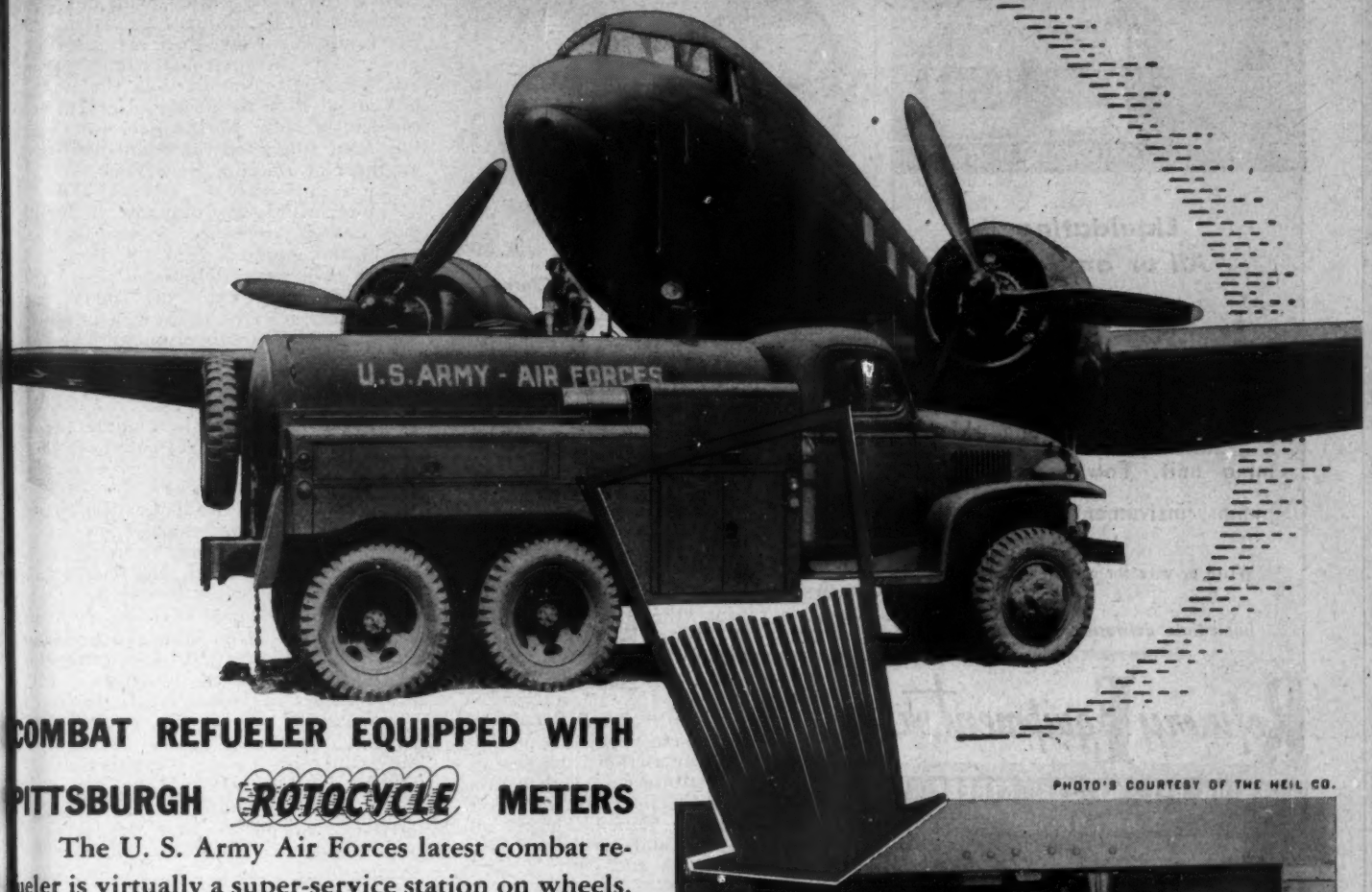
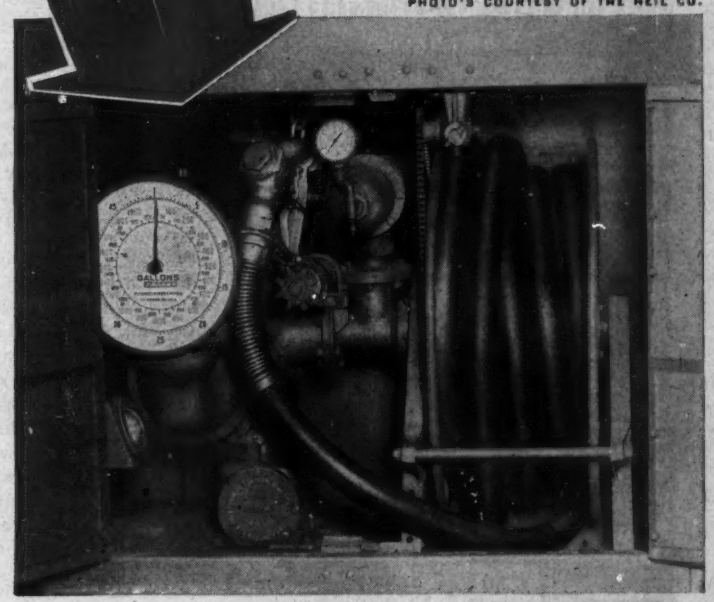



## COMBAT REFUELER EQUIPPED WITH PITTSBURGH *ROTOCYCLE* METERS

The U. S. Army Air Forces latest combat refueler is virtually a super-service station on wheels. It is designed for use at advanced air strips. Only slightly larger than a jeep, highly versatile in use and maneuverable in action, this refueler provides another vital link in the chain with which our armed forces are enmeshing the Axis.

Highly versatile too, are the Pittsburgh Rotocycle Meters through which these refuelers service combat aircraft. Large capacity and free operation with extremely low pressure absorption make Rotocycle Meters ideally suited to the exacting requirements of this service.

PHOTO'S COURTESY OF THE HEIL CO.



Close-up view of hose reel and meter compartment on side of combat refueler showing Model B-3 Rotocycle Meter mounted on strainer base. This refueler has a capacity of 750 gallons and is so designed that it may be quickly converted to dispense either high octane gasoline or aircraft engine lube oil.

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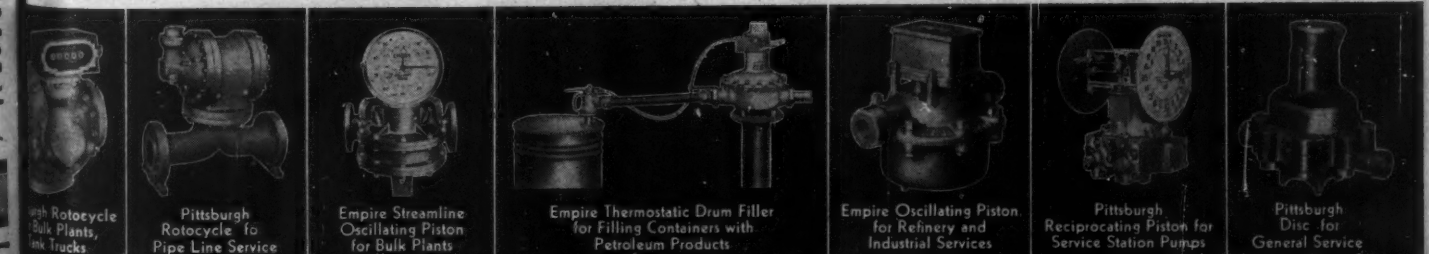

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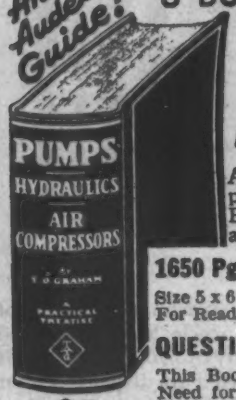


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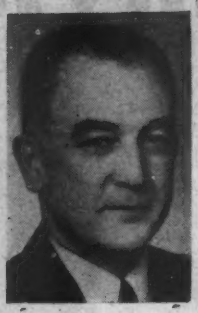

H. C. Clarke

with the company since 1922 and lately has been sales engineer at Buffalo, New York.

The company also has opened a new branch office in the Citizens State Bank Building, Houston, to serve Louisiana and Texas with exception of the Panhandle section. D. D. Ault, who has been resident sales engineer for the company at Houston since 1936, will be in charge. Ault is a graduate of Arkansas university with a degree in electrical engineering, and studied a year at the Chicago Central Station Institute before becoming associated with Oklahoma Power Company in 1925. He joined The Bristol Company in 1926 and served at Pittsburgh, Philadelphia and New York, in addition to two years of special work at the factory before going to Houston.

D. D. Ault

**Ross Heater & Manufacturing Company,** Buffalo, New York, has appointed Arleigh W. Anderson its special representative for Southern California, with offices at 164 South Central Avenue, Los Angeles 12. Anderson has had 22 years active experience in the sales-engineering and development of power-plant and marine equipment. Opening of this office gives the company representation at four West Coast points, the others being a direct factory office at San Francisco and sales offices at Portland and Seattle.

A. W. Anderson

**Sterling Packing & Gasket Company,** Houston, announces appointment of J. E. Parkin as chief engineer in charge of research. Parkin graduated from North Carolina State College in 1939, and has done development and research work for the New Bedford Rayon Company, and Calco Chemical Division of American Cyanamid Company. For the past year, Parkin has been in the technical service department of Pan American Refining Corporation at Texas City.

J. E. Parkin

**The Brown Instrument Company** has transferred I. K. Farley, who has been representing the industrial division at St. Louis, to New York as sales engineer for the petroleum engineering and contracting industry in the metropolitan area, with headquarters at the company's New York office. Ed Crane has been appointed the company's sales engineer at Buffalo, New York.

**Walter Kidde & Company,** Belleville, New Jersey, announces purchase of the assets and goodwill of U. S. Fire Protection Company, Hoboken and Milwaukee, manufacturers of "Ingas" gas-generating systems, and will fulfill its contracts with the government. The purchaser plans new applications for post-war use to be developed through redesigning of the device to combat hazardous conditions in manufacturing and processing industries handling flammable materials.

**The National Radiator Company,** Johnstown, Pennsylvania, announces that David M. Ramsey, formerly New England sales engineer, has been transferred to headquarters as assistant manager of the Industrial Division, of which W. B. duPont is manager. C. S. Whitman was appointed sales engineer for the Texas-Louisiana territory, with headquarters at Houston. He has been a consulting petroleum engineer in Detroit, where he supervised erection and modernization of a number of refineries. During 1941-1942, he was division sales representative in the Michigan territory. Edward A. Bertram, formerly chief engineer of the heat exchanger de-


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*Efficient Equipment*
FOR THE PETROLEUM
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*PORTABLE & PERMANENT MIXERS*
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# Edward
# GAGE VALVES

FOR services where bar stock valves are often used—gage, meter, dead end and instrument lines, pump vents and Diesel and gas engines—Edward Fig. 152 gage valves have the advantage of much greater strength.

Because they are drop forged steel, the bodies of Edward gage valves have sounder structure and greater strength than bodies machined from a bar. For non-shock service up to 4000 lb at 150 F and in steam service up to 600 lb at 750 F. Made to customary Edward precision and quality standards, yet remarkably low in price because of production runs.



## DESIGN DETAILS

Rugged, functional design qualifies Edward Fig. 152 gage valves for long life in tough service. Notice exclusive safety taper threaded bonnet joint, EValloy stainless steel stem with semi-needle disk, knobbed handwheel for easy grip and leverage, back seating shoulder to prevent backing stem out of bonnet and to permit repacking under pressure. Bonnets and packing nuts are EValized to cut corrosion and wear.

## DIMENSIONS AND RATINGS

4000 lb at 150 F

600 lb at 750 F — 475 lb at 1000 F

### DIMENSIONAL DETAILS

| SIZE | 1/8" | 1/4" | 3/8" | 1/2" |
|---|---|---|---|---|
| End to end—Globe | 1 13/16 | 1 13/16 | 2 1/4 | 2 3/4 |
| Center to end—Angle | 29/32 | 29/32 | 1 1/8 | 1 3/8 |
| Center to top—Open | 3 5/8 | 3 5/8 | 3 1/8 | 4 |
| Port diameter | 1/8 | 5/16 | 1/4 | 3/8 |
| Weight—lb | 1 | 1 | 1 1/4 | 1 1/2 |

For illustrations, dimensions and descriptions of the Edward line of cast and forged steel valves write for a free copy of the new Edward BETTER VALVES Catalog No. 102.

**THE EDWARD VALVE & MFG. CO., INC., • EAST CHICAGO, INDIANA**

**EDWARD *Steel* VALVES**

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**LAMINATED PHENOLIC PLASTICS**

As the plastic material of these rings is practically self-lubricating, temporary loss of lubricant will not affect the life of the piston rings or the liners.

Grit and scale become embedded in the plastic and do not scrape liner as with metal rings.

*SHOCK RESISTANCE . . . RESISTANCE TO ABRASION AND WEAR . . . HIGH STRENGTH WITH LOW WEIGHT* make Phenolic Plastics ideal for:

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ENGINEERS familiar with these excellent properties of Laminated Phenolic Plastics are daily finding more and more advantageous uses for them.

**LARGEST STOCK of Tubing and most comprehensive stock of Laminated Phenolic Rods and Sheets in the Southwest.**

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partment of the Lummus Company, and more recently general manager of Heat Transfer Products, Inc., is now in charge of the design of heat equipment for oil refineries and power plants, and of sales in the New York area. He is located in the National Radiator Company's office at 60 East 42nd Street.

**Fisher Governor Company,** Marshalltown, Iowa, has announced appointment of Johnson and Scott, Dermon Building, as its sales representative in Memphis, Tennessee. Territory to be handled includes parts of Kentucky, Tennessee, Missouri, Mississippi and Arkansas. Carl Johnson has been for 20 years sales engineer for Uhrich Supply Company, Fisher Governor Company's representative at Kansas City. Ed E. Scott for the past 2 years has been representative for Ohio Injector Company. From 1930 to 1942 he was with Century Engineering Corporation.

**General Electric Company** announces that Robert S. Peare, manager of publicity and broadcasting for the company since 1940, and chairman of the company's general advertising committee, has been elected a vice president. In his new position, Peare will direct the company's advertising, broadcasting, and general publicity activities as a member of the president's staff. He began his service with the company in its accounting department in 1922, following graduation from the University of Michigan. In 1926 he was elected secretary-treasurer of Maqua Company in Schenectady, and three years later became its general manager. In 1934 he was elected president, a post he continues to hold, and in 1940 was named G-E publicity manager.

**The Dallas Division of Revere Copper and Brass Incorporated** has opened a district sales office at 1225 Circle Tower, Indianapolis, Indiana, with P. H. Anderson as manager. Anderson has been with the organization at Chicago since 1922. The new office will handle copper and brass mill products, sales and aluminum and magnesium items in the Indiana territory to be handled as heretofore from the Chicago office.

**Oakite Products, Inc.,** 22 Thames Street, New York 6, recently completed its third war production conference on cleaning, de-scaling, de-rusting and related production and maintenance operations. Field technical service representative and members of the company's laboratory staffs met in New York, Chicago and Los Angeles, for the purpose of collating field experience in expediting cleaning procedures.

**Worthington Pump and Machinery Corporation** has announced the appointment of Thomas J. Kehane, of East Orange, New Jersey, as commercial vice president in charge of the corporation's Pacific Coast activities. He will make his headquarters in new offices to be opened July 1 at San Francisco. He will likewise supervise the territory served by its Salt Lake City district office.

Kehane started with the organization as a 14-year-old office boy in July, 1915. He has been with the corporation continuously ever since, for the last 19 years in the sales department. He has

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**SPECIFICATIONS for a GOOD COOLING TOWER TREATMENT**

1. Kill existing algae (all types).
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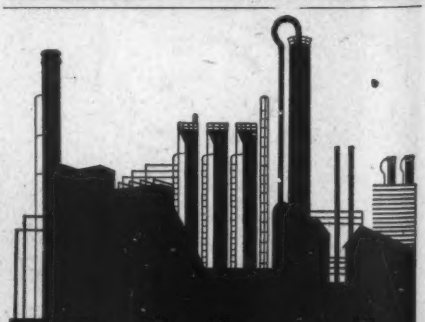

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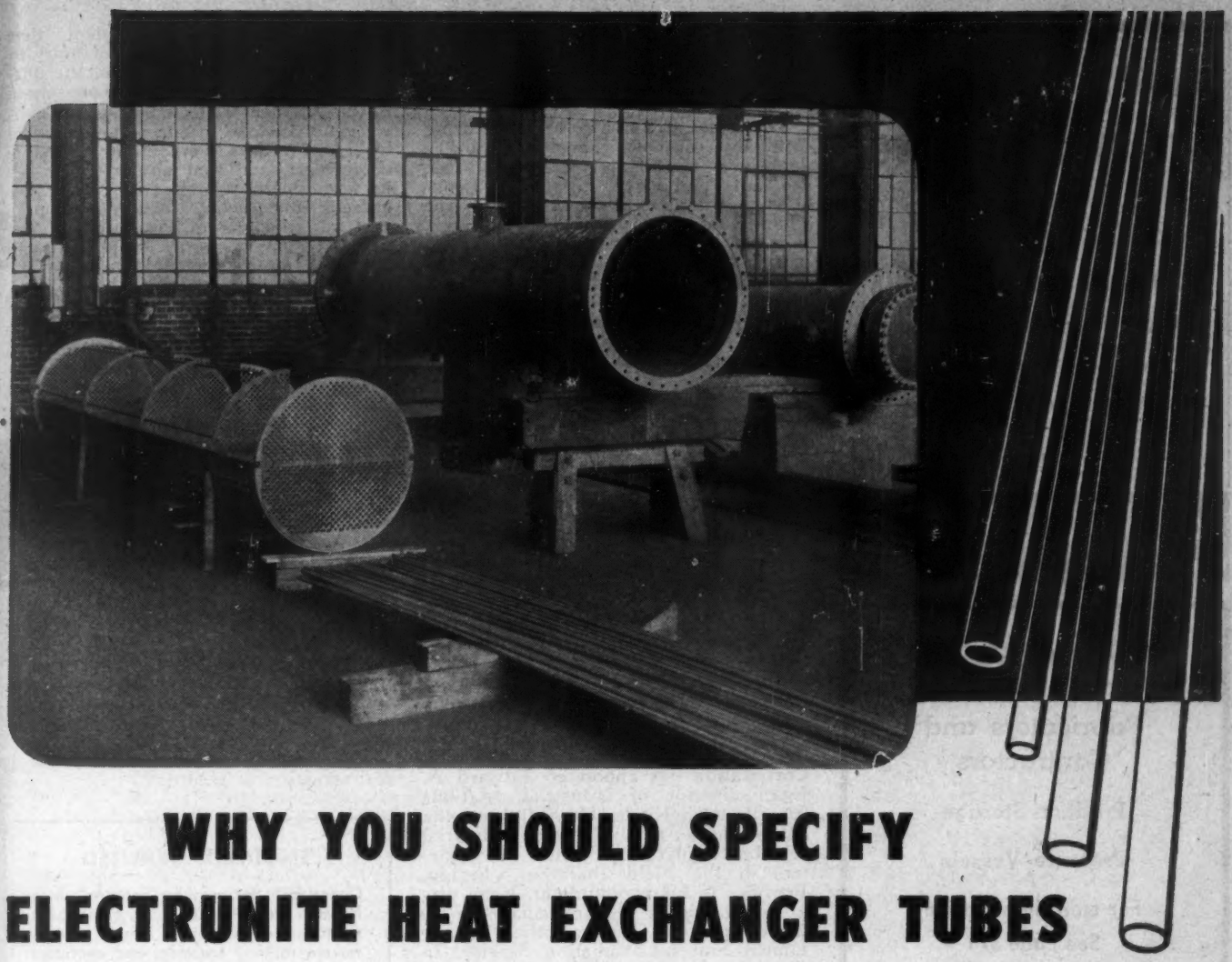

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Electric resistance welding, as employed in the manufacture of Republic ELECTRUNITE Heat Exchanger Tubes, is the only process today which consistently produces tubes with these advantages: (1) uniform roundness; (2) uniform diameter; (3) uniform wall thickness; (4) uniform high ductility; (5) fine surface uniformly free from scale; (6) uniform freedom from concealed defects.

Because of these advantages, ELECTRUNITE Heat Exchanger Tubes slide through tube sheet holes without difficulty, expand and roll in to tight fits easily and quickly, make positive joints, reduce installation costs, retard corrosion, assure safe service and low maintenance cost.

More than 120,000,000 feet of ELECTRUNITE Tubes installed in every type of steam generating and heat transfer equipment in all kinds of service prove these statements.

And some 30,000 miles of Republic Line Pipe, 50,000,000 feet of oil well casing and tubing, and more than 1,000,000,000 feet of mechanical and aircraft tubing in carbon, alloy and stainless steels, produced by the same process, have proved *indisputably* the soundness, safety and economy of Republic Electric Weld Tubular Products.

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*For Insulation*

Emulsified asphalt containing asbestos fibers—will not support combustion — long durability — dries smooth and black.

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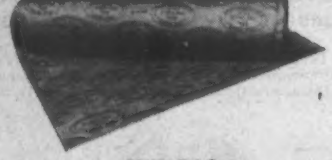

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A strong, high quality plant fibre sheet for use on all types parallel surfaces and flanges. Sterlpac becomes even more tough in service in gasoline, oils and water. Due to its density and resiliency, it is very adaptable to varied applications in minimum thickness. Style 425 Sterlpac—sheet. Style 4250 Sterlpac—Gaskets.

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Sterling Packing & Gasket Co., Inc.
1701 Nance St., Houston, Texas

Sterling
MEANS QUALITY

advanced through various positions to his most recent assignment as manager of New Jersey sales and assistant manager of the New York district office.

**The Edward Valve & Manufacturing Company,** East Chicago, Indiana, has appointed Herr-Harris Company, 545 William Penn Place, Pittsburgh, Pennsylvania, its representative in the Charleston and Central West Virginia territory. The latter has been the company's representative in the Pittsburgh area for 25 years.

**Lucey Products Corporation,** Tulsa, announces that it has taken over exclusive distribution of Shaw burner products, and that F. D. Morgan has been appointed manager of the heating department, with headquarters at Tulsa. He will direct sales, service, and installation of heating and heating-control equipment. Morgan was formerly sales manager for Shaw Burner Company.

**Moorlane Company,** Tulsa, has opened two new district offices, at 119 Hendricks Building, Odessa, Texas, with G. P. Jackson as manager, and at 3103 Apco Tower, Oklahoma City, with G. H. Jennings, manager. The company's other offices are at Houston, Kansas City, Amarillo and Wichita, with warehouse stocks at Tulsa, Kansas City, Amarillo and Oklahoma City.

**General American Transportation Corporation** has appointed Edward A. Egan director of industrial relations for all its divisions. He will head the corporation's newly-created industrial relations department, with headquarters in the Field Building, Chicago. Previous to his appointment, Egan was a commissioner of conciliation, attached to the Chicago office of the United States Conciliation Service. In that capacity, he gained wide recognition from both companies and unions for his untiring and impartial efforts in the interests of industrial peace. Following extended university studies in this country and Canada in which he specialized in personnel and labor relations courses, he advanced through various production jobs in the steel mills and other plants to industrial relations work. Early in 1942, he joined the Chicago staff of the United States Conciliation Service.

## Carnegie-Illinois Steel Exonerated of Fraud Charge

"We are happy to have the public know that the unfair and unsubstantiated accusations made by the Truman Committee of the delivery by Carnegie-Illinois of defective plates have been completely refuted," J. L. Perry, president of Carnegie-Illinois Steel Corporation, United States Steel Corporation subsidiary, said in commenting upon acquittal May 23 of Carnegie-Illinois in the criminal suit prosecuted by government against it in the federal court at Pittsburgh. "No witness," Perry continued, "testified either before the Truman Committee or before the federal court at Pittsburgh that any defective steel plates were ever supplied by Carnegie-Illinois Steel Corporation from Irvin Works or elsewhere.

"About a year ago," he said, "when indictments were found against Carnegie-Illinois Steel Corporation relative to alleged false reports of tests of steel plates at Irvin Works, I stated that Carnegie-Illinois was confident that when it was afforded the opportunity to present in court the full facts, the outcome would be complete exoneration. Such statement reflected my firm conviction that none of the plates supplied by Irvin Works were either defective or inferior, and that any irregularities in test reports which might have occurred concerned relatively unimportant variations from the specifications. My statement has since been proved to have been entirely accurate.

"After an exhaustive three-weeks trial, just concludd before Judge Robert M. Gibson in the United States District Court at Pittsburgh, such complete exoneration has been obtained. Today the jury in that case acquitted Carnegie-Illinois of the charges contained in 47 counts of an indictment that it had falsely certified tests on certain plates furnished to or for various government agencies. During the trial Carnegie-Illinois introduced evidence to establish the actual heat numbers of the steel involved in each of these 47 counts, as well as evidence to prove that all of the steel in question had in fact been properly tested and had met the chemical and physical requirements of the contract specifications.

"Judge Gibson directed a verdict of acquittal on another indictment charging Carnegie-Illinois with the destruction of pertinent records. The government was unable to present any evidence connecting Carnegie-Illinois with a destruction of records."

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**Opportunity for engineer not over 45 in Houston area with nationally known heat exchanger manufacturer. Should be conversant refinery processes and operation and familiar design rating and construction heat exchangers. Previous experience selling heat exchangers valuable but not essential. Salary basis. Those employed at their highest skills in war work will not be considered.**

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**FOR SALE: Steel gate valves, mostly flanged, some 300, 600, 900, and 1500 pound. Sizes 2, 2½, 3, 4, and 6 inch various pressures. Special trim if desired. Also few globe valves.**

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**WANTED—INSTRUMENT MEN**

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